HANDBOOK

OF

HEMISTRY AND PHYSICS

A READY-REFERENCE POCKET BOOK
OF CHEMICAL AND PHYSICAL DATA

FIFTH EDITION

MPILED FROM THE MOST RECENT AUTHORITATIVE SOURCES

THE CHEMICAL RUBBER CO.
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PREFACE

IN compliance with the requests of hundreds of our friends for a small but comprehensive book of reference on chemical and physical topics, we have designed and compiled this Handbook of Chemistry and Physics.

In its new and revised form we have aimed to present in one compact, easily portable volume a comparatively comprehensive reference book for use in the laboratory or classroom. While more complete and broader in scope than the reference material ordinarily found in the laboratory manual, it is still not a competitor of the many large and complete reference books already published, but fills, we believe, a place not hitherto occupied by any publication in this country.

We shall feel amply rewarded for our effort and expense if this volume proves to be of use and convenience to the profession whose support has been a conspicuous factor in the growth of our establishment.

The material here included has been carefully selected by W. R. Veazey, Ph.D., of the Chemistry Department, and Charles D. Hodgman, B.S., of the Department of Physics of the Case School of Applied Science. The compilers have been guided in their selections by the suggestions of more than a thousand members of high standing in the Chemical and Physical profession.

A large number of the tables are the result of compilation from various sources: the original authority or the source of information being stated where possible. Special mention should be made of the use of the "Smithsonian Physical Tables," from which several tables have been taken without alteration, while others are partly compiled from similar tables in that volume. We are also indebted to Julius Springer, publisher of the "Chemiker Kalender," a reference-book of more than a thousand pages, for permission to use certain material.

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from the following: Collins, "The Design and Construction of Induction Coils," Munn and Co., publisher; Miller, "Laboratory Physics," Ginn and Co., publisher; Noyes, "Qualitative Analysis," Macmillan and Co., publisher; Perkins, "Introduction to General Thermodynamics," John Wiley and Sons, publisher; Talbot, "Quantitative Analysis," Macmillan and Co., publisher; Young, "General Astronomy," Ginn and Co., publisher; Cohn, "Indicators and Test-papers," John Wiley and Sons, publisher.

For general reference and to supply occasional numerical values use has been made of the following standard works:

Landolt - Bornstein - Meyerhoffer, "Physikalisch - chemische Tabellen"; "Recueil de Constantes Physiques"; The Standard Dictionary.

In the present edition about sixty pages of new material have been added, following as far as possible the suggestions of users of the Handbook. Among the important additions, are a table of the physical constants of the more common organic compounds and a five-place logarithm table, both of which will, we believe, add materially to the usefulness of the volume.

We desire to express our appreciation and thanks to the many persons who have co-operated with us in the preparation of this book.

THE CHEMICAL RUBBER COMPANY,
Cleveland, Ohio.

PREFACE TO THE FIFTH EDITION

The Handbook has been thoroughly revised and substantially enlarged under the direction of our former compiler, Mr. Hodgman, assisted by Prof. M. F. Coolbaugh of the Department of Chemistry at Case School of Applied Science.

An invitation to the users of the Handbook to make suggestions as to further improvement met with a generous response, and the compilers were under the responsibility of selecting from a large number of items the material which might be added without sacrificing the present compactness and low price of the volume. A large number of tables have been more or less completely revised. A new and more complete table of gravimetric factors has replaced the former table. Among the important tables which have been added are: heats of formation of important compounds, an anion analysis scheme, flame and bead tests, natural logarithms, algebraic formulæ, elementary derivatives and integrals. Common names of chemical compounds have been added to the index, the chemical names are given and the page numbers are those on which the chemical formulæ and properties of the substances will be found.

Material has been taken by permission from Thomsen's Thermochemistry, Longmans, Green and Co., publishers.

THE CHEMICAL RUBBER COMPANY
Cleveland, Ohio,
July 17, 1916.

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Acetic Acid.—Emetics, magnesia, chalk, soap, oil.

Arsenic, Rat Poison, Paris Green.—Milk, raw egg, sweet oil, lime water, flour and water.

Carbolic Acid.—Any soluble non-toxic sulphate, after provoking vomiting with zinc sulphate; uncoöked white of egg in abundance, milk of lime, saccharate of calcium, olive or castor oil with magnesia in suspension, ice, washing the stomach with equal parts water and vinegar; give alcohol or whiskey or about four fluid ounces camphorated oil at one dose.

Chloroform, Chloral, Ether.—Dash cold water on head and chest, artificial respiration.

Hydrochloric Acid.—Magnesia, alkali carbonates, albumen, ice.

Hydrocyanic or Prussic Acid.—Hydrogen peroxide internally, and artificial respiration, breathing ammonia or chlorine from chlorinated lime, ferrous sulphate followed by potassium carbonate, emetics, warmth.

Iodine.—Emetics, stomach siphon, starchy foods in abundance, sodium thiosulphate.

Lead Acetate.—Emetics, stomach siphon, sodium, potassium or magnesium sulphates, milk, albumen.

Mercuric Chloride or Corrosive Sublimate.—Zinc sulphate, emetics, stomach siphon, white of egg, milk, chalk, castor oil, table salt, reduced iron.

Nitrate of Silver.—Salt and water.

Nitric Acid.—Same as for hydrochloric acid.

Opium, Morphine, Laudanum, Paregoric, etc.—Strong coffee, hot bath. Keep awake and moving at any cost.

Phosphoric Acid.—Same as for hydrochloric.

Sodium Hydroxide or Potassium Hydroxide.—Vinegar, lemon juice, orange juice, oil, milk.

Sulphuric Acid.—Same as for hydrochloric acid with the addition of soap or oil.

Sulphurous Acid or Sulphur Dioxide.—Mustard plaster on chest; narcotics, expectorants.

HANDBOOK OF CHEMISTRY AND PHYSICS

GENERAL CHEMICAL TABLES

INTERNATIONAL ATOMIC WEIGHTS

1916

Name	Symbol	Atomic weight	Principal valence
Aluminum	Al	27.1	3
Antimony, stibium	Sb	120.2	3 or 5
Argon	A	39.88	0
Arsenic	As	74.96	3 or 5
Barium	Ba	137.37	2
Bismuth	Bi	208.0	3 or 5
Boron	B	11.0	3
Bromine	Br	79.92	1
Cadmium	Cd	112.40	2
Cæsium	Cs	132.81	1
Calcium	Ca	40.07	2
Carbon	C	12.005	4
Cerium	Ce	140.25	4 or 3
Chlorine	Cl	35.46	1
Chromium	Cr	52.0	2, 3 or 6
Cobalt	Co	58.97	2 or 3
Columbium, niobium	Cb	93.5	5
Copper	Cu	63.57	1 or 2
Dysprosium	Dy	162.5	3
Erbium	Er	167.7	3
Europium	Eu	152.0	3
Fluorine	F	19.0	1
Gadolinium	Gd	157.3	3
Gallium	Ga	69.9	3
Germanium	Ge	72.5	4
Glucinum, beryllium	Gl	9.1	2
Gold, aurum	Au	197.2	1 or 3
Helium	He	4.00	0
Holmium	Ho	163.5	3
Hydrogen	H	1.008	1
Indium	In	114.8	3
Iodine	I	126.92	1
Iridium	Ir	193.1	4
Iron, ferrum	Fe	55.84	2 or 3
Krypton	Kr	82.92	0
Lanthanum	La	139.0	3
Lead, plumbum	Pb	207.2	2 or R
Lithium	Li	6.94	1
Lutecium	Lu	175.0	3
Magnesium	Mg	24.32	2
Manganese	Mn	54.93	2, 4, 6 or 7
Mercury, hydrargyrum	Hg	200.6	1 or 2
Molybdenum	Mo	96.0	3, 4 or 6
Neodymium	Nd	144.3	3
Neon	Ne	20.2	0
Nickel	Ni	58.68	2 or 3
Niton, Ra. emanation	Nt	222.4	–
Nitrogen	N	14.01	3 or 5
Osmium	Os	190.9	2, 3, 4 or 8
Oxygen	O	16.00	2
Palladium	Pd	106.7	2 or 4
Phosphorus	P	31.04	3 or 5
Platinum	Pt	195.2	2 or 4
Potassium, kalium	K	39.10	1
Praseodymium	Pr	140.9	3
Radium	Ra	226.0	2
Rhodium	Rh	102.9	3
Rubidium	Rb	85.45	1
Ruthenium	Ru	101.7	6 or 8
Samarium	Sa	150.4	3
Scandium	Sc	44.1	3
Selenium	Se	79.2	2, 4 or 6
Silicon	Si	28.3	4
Silver, argentum	Ag	107.88	1
Sodium, natrium	Na	23.00	1
Strontium	Sr	87.63	2
Sulphur	S	32.06	2, 4 or 6
Tantalum	Ta	181.5	5
Tellurium	Te	127.5	2, 4 or 6
Terbium	Tb	159.2	3
Thallium	Tl	204.0	1 or 3
Thorium	Th	232.4	4
Thulium	Tm	168.5	3
Tin, stannum	Sn	118.7	2 or 4
Titanium	Ti	48.1	4
Tungsten, wolframium	W	184.0	6
Uranium	U	238.2	4 or 6
Vanadium	V	51.0	3 or 5
Xenon	Xe	130.2	0
Ytterbium	Yb	173.5	3
Yttrium	Yt	89.0	3
Zinc	Zn	65.37	2
Zirconium	Zr	90.6	4

MOLECULAR WEIGHTS AND THEIR LOGARITHMS

Compound	Mol. wt.	Log.	Compound	Mol. wt.	Log.
Aluminum			Hydrogen		
Al_2O_3	102.20	2.00945	H_2O	18.016	1.25565
$Al_2(OH)_6$	156.25	2.19381	Iodine		
Antimony			AgI	234.80	2.37070
Sb_2S_5	400.70	2.60382	HI	127.93	2.10697
Sb_2S_3	336.58	2.52609	PbI_2	461.04	2.66374
Sb_2O_3	288.40	2.46000	Iron		
Sb_2O_5	320.40	2.50569	FeO	71.84	1.85637
Arsenic			Fe_2O_3	159.68	2.29325
$Mg_2As_2O_7$	310.56	2.49214	Lead		
$(MgNH_4AsO_4)_2 . H_2O$	380.66	2.58054	$PbSO_4$	303.26	2.48182
			PbS	239.26	2.37887
As_2S_5	310.22	2.49167	PbO	223.00	2.34830
As_2S_3	246.10	2.39111	$PbCl_2$	278.12	2.44423
As_2O_3	197.92	2.29649	$PbCrO_4$	323.20	2.50947
As_2O_5	229.92	2.36157	Lithium		
Barium			LiCl	42.40	1.62737
$BaSO_4$	233.43	2.36816	Li_2SO_4	109.94	2.04116
BaO	153.37	2.18574	Li_2O	29.88	1.47538
$BaCO_3$	197.37	2.29528	Li_2CO_3	73.88	1.86853
$BaCrO_4$	253.37	2.40374	Li_3PO_4	116.09	2.06479
Bismuth			Magnesium		
Bi_2O_3	464.00	2.66652	$Mg_2P_2O_7$	222.72	2.34772
Bi_2S_3	512.18	2.70942	MgO	40.32	1.60556
BiOCl	259.46	2.41407	$Mg(NH_4)AsO_4 + 6H_2O$	289.42	2.46153
Bromine					
AgBr	187.80	2.27370	$Mg_2As_2O_7$	310.56	2.49214
HBr	80.93	1.90811	$MgSO_4$	120.38	2.08055
Cadmium			Manganese		
CdS	144.45	2.15972	$MnSO_4$	150.99	2.17895
CdO	128.40	2.10857	MnS	86.99	1.93947
Calcium			Mn_3O_4	228.79	2.35944
CaO	56.07	1.74873	Mn_2O_3	157.86	2.19828
$CaSO_4$	136.13	2.13395	MnO	70.93	1.85083
$CaCO_3$	100.07	2.00030	$KMnO_4$	158.03	2.19874
Carbon			Mercury		
CO_2	44.00	1.64345	HgS	232.66	2.36672
CN	26.01	1.41514	HgO	216.60	2.33566
CO	28.00	1.44716	Hg_2O	417.20	2.62034
HCN	27.02	1.43169	Hg_2Cl_2	472.12	2.67405
Chlorine			Nickel		
AgCl	143.34	2.15637	NiO	74.68	1.87320
HCl	36.47	1.56194	$NiSO_4$	154.74	2.18960
Chromium			Nitrogen		
Cr_2O_3	152.00	2.18184	N_2O_5	108.02	2.03350
CrO_3	100.00	2.00000	N_2O_3	62.01	1.79246
$PbCrO_4$	323.10	2.50934	$(NH_4)Cl$	53.50	1.72835
$BaCrO_4$	253.37	2.40374	$(NH_4)_2SO_4$	132.14	2.12103
Cobalt			Phosphorus		
CoO	74.97	1.87489	$Mg_2P_2O_7$	222.72	2.34776
Co_3O_4	240.91	2.38186	$Ag_4P_2O_7$	605.60	2.78219
$K_3Co(NO_2)_6$	452.33	2.65546	P_2O_5	142.08	2.15253
Copper			PH_3	34.06	1.53225
CuO	79.57	1.90075	Ag_3PO_4	418.68	2.62188
Cu_2S	159.20	2.20194	Platinum		
Fluorine			K_2PtCl_6	486.16	2.68678
CaF_2	78.07	1.89248	$(NH_4)_2PtCl_6$	444.04	2.64742
HF	20.008	1.30121	Potassium		
$BaSiF_6$	279.67	2.44665	KCl	74.56	1.87251
K_2SiF_6	220.50	2.34341	K_2SO_4	174.26	2.24120
H_2SiF_6	144.32	2.15932	K_2PtCl_6	486.16	2.68678

MOLECULAR WEIGHTS AND THEIR LOGARITHMS (Cont.)

Compound	Mol. wt.	Log.	Compound	Mol. wt.	Log.
Potassium (*Cont.*)			Strontium		
K_2O	94.20	1.97405	$SrSO_4$	183.69	2.26409
K_2SiF_6	220.50	2.34341	$SrCO_3$	147.63	2.16917
Silicon			SrO	103.63	2.01550
SiO_2	60.30	1.78032	Sulphur		
SiF_4	104.30	2.01828	As_2S_3	246.10	2.39111
H_2SiF_6	144.32	2.15932	CdS	144.46	2.15975
K_2SiF_6	220.50	2.34341	H_2S	34.08	1.53250
$BaSiF_6$	279.67	2.44665	SO_2	64.06	1.80659
Silver			SO_3	80.06	1.90342
Ag_2O	231.76	2.36504	H_2SO_4	98.08	1.99158
$AgBr$	187.80	2.27370	Tin		
$AgCl$	143.34	2.15367	SnO_2	151.00	2.17898
AgI	234.80	2.37070	SnO	135.00	2.13033
$AgCN$	133.89	2.12675	Zinc		
Ag_3PO_4	418.68	2.62188	ZnS	97.43	1.98869
Sodium			ZnO	81.37	1.91046
$NaCl$	58.46	1.76686			
Na_2SO_4	142.06	2.15247			
Na_2CO_3	106.00	2.02531			
Na_2O	62.00	1.79239			

COMPOSITION OF SOME TYPICAL ENGINEERING ALLOYS

	IRON	TIN	ANTIMONY	LEAD	COPPER	ZINC	BISMUTH	PHOS.
Bell metal		22.0			78.0			
Brass					72.0	28.0		
Brass (yellow)					60.0	40.0		
Bronze for bearings		16.0			82.0	2.0		
Speculum metal		33.4			66.6			
Muntz metal					60.0	40 0		
Mosaic gold					65.0	35.0		
Gun metal		91.0				9.0		
Bronze		94.0			1.0	5.0		
Babbitt metal		45.5	13.0	40.0	1.5			
Britannia metal		90.0	10.0					
Pewter		80.0		20.0				
Soft solder		50.0		50.0				
Tobin bronze	0.2	0.9		0.4	61.2	37.3		
Phosphor bronze		10.0	9.5		79.7			0.8
Rose metal		22.9		27.1			50.0	
Car-box metal	0.61		14.38	84.33		0.68		
"B" Alloy P. R. R.		8.0		15.0	77.0			trace
White metal		82.0	12.0		6.0			
Type metal		3.0	15.0	82.0				

	Cu	Zn	Ni	Mn
Constantin	60	..	40	..
German silver	60	25	15	..
Manganin	84	..	4	12

PHYSICAL CONSTANTS OF

This table is compiled from Landolt-Börnstein

No.	Name	Derivation	Symbol	At. wt.	Specific gravity*	Principal valence
1	Aluminum...	L. *alumen*, alum....	Al	27.1	2.70 20° C.	3
2	Antimony...	L. *antimonium*.....	Sb	120.2	6.62 20°	3 or 5
3	Argon, gas...	Gr. *argos*, inactive..	A	39.88	1.38 A	0
4	liquid.....	....	A	39.88	1.405–186°	0
5	Arsenic, cryst.	L. *arsenicum*.......	As	74.96	5.73	3 or 5
6	amorph....	....	As	74.96	4.72 14°	3 or 5
7	Barium.....	Gr. *barys*, heavy....	Ba	137.37	3.80 0°	2
8	Bismuth.....	Unknown..........	Bi	208.0	9.78 20°	3 or 5
9	Boron, amor.	*Borax*............	B	11.0	2.45	3
10	crystal....	....	B	11.0	2.54	3
11	Bromine, gas	Gr. *bromos*, stench..	Br	79.92	5.87 A	1
12	liquid.....	....	Br	79.92	3.12 20°	1
13	Cadmium ...	Gr. *kadmia*, calamine	Cd	112.4	8.65 20°	2
14	Caesium.....	L. *caesius*, sky blue.	Cs	132.81	1.87 26°	1
15	Calcium.....	L. *calx*, lime.......	Ca	40.07	1.54 29°	2
16	Carbon, amor.	L. *carbo*, charcoal...	C	12.0	1.88	2 or 4
17	graphite...	....	C	12.0	2.25	2 or 4
18	diamond ..	....	C	12.0	3.51	2 or 4
19	Cerium......	Planet *Ceres*.......	Ce	140.25	6.92 25°	4 or 3
20	Chlorine, gas	Gr. *chloros*, green...	Cl	35.46	2.49 A	1
21	liquid.....	....	Cl	35.46	1.51–34°	1
22	Chromium...	Gr. *chroma*, color...	Cr	52.0	6.92 20°	3 or 6
23	Cobalt......	G. *kobold*, goblin ...	Co	58.97	8.72 21°	2 or 3
24	Columbium, niobium	*Columbia*..........	Cb	93.5	8.4	3 or 5
25	Copper......	*Cyprus*............	Cu	63.57	8.93–8.95	2 or 1
26	Dysprosium .	Gr. hard to speak with	Dy	162.5	....	3
27	Erbium......	*Yrtterby*, town in Sweden .	Er	167.7	4.77	3
28	Europium...	*Europe*............	Eu	152.0	....	3
29	Fluorine, gas	L. *fluor*, flow.......	F	19.0	1.31 A	1
30	liquid.....	....	F	19.0	1.14–200°	1
31	Gadolinium..	*Gadolin*, a Russian..	Gd	157.3	1.31	3
32	Gallium.....	L. *Gallia*, France...	Ga	69.9	5.94 23°	3
33	Germanium .	L *Germania*, Germany	Ge	72.5	5.47 20°	4
34	Glucinum, beryllium	Gr. *glykys*, sweet...	Gl	9.1	1.85	2
35	Gold........	Anglo-Saxon, *gold* ..	Au	197.2	19.32 17.5°	3 or 1

* Specific gravities marked A are referred to air.

THE ELEMENTS

Phys.-Chem. Tabellen and the Standard Dictionary.

No.	Melting point °C	Boiling point °C	Discovered	Discoverer	Where found
1	658	1800	1828	Wohler	In many rocks. Most abundant metal.
2	630	1440	1450	Valentine	Chiefly as sulphide and in various metallic ores.
3	−187.9	−186.1	1894	Rayleigh	Rare element in air.
4	....	....	....	....	....
5	sublimes	450	1694	Schroder	As sulphide and in metallic ores.
6	....	....	....	....	....
7	850	950	1808	Davy	In barite and witherite.
8	269	1436	1450	Valentine	As sulphide and in rare minerals.
9	infusible	subl. 3500	1808	Davy	In borax and some minerals.
10	....	....	....	....	....
11	−7.3	63	1828	Balard	In sea water and natural brines.
12	....	....	....	....	....
13	321	778	1817	Stromeyer	In zinc ores.
14	26.4	670	1860	Bunsen	In lepidolite, pollucite, and some mineral springs.
15	805	....	1808	Davy	In limestone and other rocks.
16	infusible	subl. 3500	Pre 3500	historic	In coal, limestone and all organic matter.
17	....	....	....	....	....
18	....	....	....	....	....
19	645	....	1803	Berzelius	In cerite and rare minerals.
20	−102	−33.6	1774	Scheele	In common salt and other chlorides.
21	....	....	....	....	....
22	1520	2200	1797	Vauquelin	In chrome-iron ore.
23	1478	....	1773	Brandt	In many metallic ores.
24	1950	....	1801	Hatchett	In columbite and rare minerals.
25	1083	2310	Pre	historic	As metal and in many ores.
26	....	....	1886	Lecoq de Boisbaudran	In holmium, samarskite, gadolinite, etc.
27	....	....	1843	Mosander	In gadolinite and rare minerals.
28	....	....	1896	Demarcay	....
29	−223	−187	1771	Scheele	In fluorite and other minerals.
30	....	....	....	....	....
31	....	....	1886	Marignac	In rare minerals as gadolinite.
32	30.15	....	1875	Boisbaudran	In certain zinc blendes.
33	958	volat. at 1350	1886	Winkler	In argyrodite, a rare mineral.
34	960	....	1828	Wohler	In beryl and several rare minerals.
35	1063	2500	Pre	historic	Generally free; rarely combined in various ores.

OH −1 CO₃

SO₄

PO₄ −3

NO₃ −1

PHYSICAL CONSTANTS OF

No.	Name	Derivation	Symbol	At. wt.	Specific gravity	Principal valence
1	Helium, gas	Gr. *helios*, the sun	He	4.00	0.137 A	0
2	liquid	.....	He	4.00	0.15 −269°	0
3	Hydrogen, gas	Gr. *hydor*, water, and *genes*, forming	H	1.008	0.0695 A	1
4	liquid	.....	H	1.008	0.070–252	1
5	Indium	From its *indigo* spectrum	In	114.8	7.12 13°	3
6	Iodine, gas	Gr. *iodes*, violet	I	126.92	8.72 A	1
7	solid	.....	I	126.92	4.94 20°	1
8	Iridium	L. *iris*, rainbow	Ir	193.1	22.42 17°	3
9	Iron, pure	Anglo-Saxon, *iron*	Fe	55.84	7.28	2 or 3
10	Krypton, gas	Gr. *Kryptos*, hidden.	Kr	82.92	2.818 A	0
11	liquid	.....	Kr	82.92	2.16–146°	0
12	Lanthanum	Gr. *lanthano*, to conceal	La	139.0	6.155	3
13	Lead	Anglo-Saxon, *lead*	Pb	207.2	11.34	2
14	Lithium	Gr. *lithos*, stone	Li	6.94	0.534	1
15	Lutecium	*Lutetia*, ancient name of Paris.	Lu	17.50	.....	3
16	Magnesium	*Magnesia*, district in Thessaly	Mg	24.32	1.74 5°	2
17	Manganese	L. *magnes*, magnet	Mn	54.93	7.42	2, 4, 6 or 7
18	Mercury	Planet *Mercury*	Hg	200.6	13.595 4°	1 or 2
19	Molybdenum	Gr. *molybdos*, lead	Mo	96.0	9.01	3 or 6
20	Neodymium	Gr. *neos*, new and *didymos*, twin	Nd	144.3	6.95	3
21	Neon	Gr. *neos*, new	Ne	20.2	0.674 A	0
22	Nickel	Sw. abbr. of kupparnickel	Ni	58.68	8.60–8.90	2 or 3
23	Nitrogen, gas	N. L., niter forming	N	14.01	0.967 A	3 or 5
24	liquid	.....	N	14.01	0.854–205°	3 or 5
25	Osmium	Gr. *osme*, odor	Os	190.9	22.48	2, 3 or 4
26	Oxygen, gas	Gr. acid former	O	16.0	1.1053 A	2
27	liquid	.....	O	16.0	1.14–184°	2
28	Palladium	Planet *Pallas*	Pd	106.7	12.16	2 or 4
29	Phosphorus, yellow	Gr. light bearing	P	31.04	1.83	3 or 5
30	red	.....	P	31.04	2.20	3 or 5
31	Platinum	Sp. *platina*	Pt	195.2	21.37	2 or 4
32	Potassium	Eng. *potash*	K	39.10	0.870 20°	1

THE ELEMENTS (Continued)

No.	Melting point °C.	Boiling point °C.	Discovered	Discoverer	Where found
1	-270	-267	1895	Ramsey and Travers	Rare element in the air and in the sun.
2	....	....	....	....	....
3	-259	-252	1766	Cavendish	Mainly in water and organic substances.
4	....	....	....	....	....
5	155	red heat	1863	Reich and Richter	In certain zinc ores.
6	119	184	1811	Courtois	Mainly in ashes of seaweeds.
7	....	....	....	....	....
8	2290	....	1803	Tennant	In iridosmine.
9	1530	2450	Pre	historic	As oxide and sulphide in nearly all rocks.
10	-169	-151.7	1895	Ramsey and Travers	Rare element in air.
11	....	....	....	....	....
12	810	....	1839	Mosander	In cerite and other rare minerals.
13	327	1525	Pre	historic	In galena and other ores.
14	186	1400	1817	Arfvedson	In lepidolite, spodumene and other rare minerals.
15	....	....	1907	Urbain and Welsbach	In samarskite and gadolinite.
16	651	1120	1829	Bussy	In sea water, magnesite and other minerals.
17	1260	....	1774	Gahn	In pyrolusite and other minerals.
18	-38.85	357.25	Pre	historic	Native and in cinnabar.
19	2535	....	1782	Hjelm	Chiefly in molybdenite.
20	840	....	1885	Welsbach	In cerite and other rare minerals.
21	-253	-239	1895	Ramsey and Travers	Rare gas in air.
22	1452	....	1751	Cronstedt	Many metallic ores.
23	-211	-195	1772	Rutherford	In air and organic matter.
24	....	....	....	....	....
25	2700	white heat	1803	Tennant	In iridosmine and native platinum.
26	-218	-182.7	1774	Priestly	In air and forms about one half the earth's crust combined in rocks, etc.
27	....	....	....	....	....
28	1549	....	1804	Wollaston	Native and in platinum and gold ores.
29	44.1	290	1669	Brandt	In bones and apatite and many minerals.
30	....	....	....	....	....
31	1755	....	1741	Wood	As native platinum.
32	62.5	712	1807	Davy	In wood ashes and many rocks.

PHYSICAL CONSTANTS OF

No.	Name	Derivation	Symbol	At. wt.	Specific gravity	Principal valence
1	Praseodymium	Gr. *praseos*, green, and *didymos*, twin	Pr	140.9	6.48	3
2	Radium.....	L. *radius*, ray......	Ra	226.0	....	2
3	Rhodium....	Gr. *rhodon*, rose....	Rh	102.9	12.44	3
4	Rubidium...	L. *rubidius*, red....	Rb	85.45	1.52	1
5	Ruthenium..	*Ruthenia*, Russia...	Ru	101.7	12.06	2, 3 or 4
6	Samarium...	*Samarski*, a Russian	Sm	150.4	7.7–7.8	3
7	Scandium...	*Scandinavia*........	Sc	44.1	....	3
8	Selenium....	Gr. *selene*, moon....	Se	79.2	4.47–4.80	2 or 4
9	Silicon......	L. *silex*, flint......	Si	28.3	2.42 cryst.	4
10	Silver.......	Anglo-Saxon, *soelfor*	Ag	107.88	10.50	1
11	Sodium.....	English, *soda*.......	Na	23.00	0.971	1
12	Strontium...	*Strontian*, town in Scotland	Sr	87.63	2.54	2
13	Sulphur, amorphous	L. *sulfur*..........	S	32.06	2.046	2, 4 or 6
14	rhombic...	....	S	32.06	2.07	2, 4 or 6
15	monoclinic	....	S	32.06	1.957	2, 4 or 6
16	Tantalum...	Gr. *tantalus*, myth..	Ta	181.5	16.6	5
17	Tellurium...	L. *tellus*, earth.....	Te	127.5	6.25	4 or 6
18	Terbium....	*Ytterby*, town in Sweden	Tb	159.2	....	3
19	Thallium....	Gr. *thallos*, budding twig	Tl	204.0	11.85	1 or 3
20	Thorium....	God *Thor*..........	Th	232.4	11.2	4
21	Thulium....	*Thule*, Northland...	Tm	168.5	....	....
22	Tin, gray....	Anglo-Saxon, *tin*...	Sn	118.7	5.85 15°	2 or 4
23	rhombic...	....	Sn	119.0	6.55	2 or 4
24	tetragonal.	....	Sn	119.0	7.298 15°	2 or 4
25	Titanium....	L. *Titanes*, sons of the earth	Ti	48.1	4.5	4 or 3
26	Tungsten, wolframium	Sw. heavy stone....	W	184.0	18.7	6
27	Uranium....	Planet *Uranus*.....	U	238.2	18.68	6
28	Vanadium...	Goddess *Vanadis*...	V	51.0	5.69	3 or 5
29	Xenon, gas..	Gr. *xenos*, strange..	Xe	130.2	4.422	0
30	liquid.....	....	Xe	130.2	3.52	0
31	Ytterbium...	*Ytterby*, town in Sweden	Yb	173.5	....	3
32	Yttrium.....	*Ytterby*...........	Y	88.7	3.80	3
33	Zinc........	G. *Zink*...........	Zn	65.37	7.00–7.19	2
34	Zirconium...	Per. *zargun*, gold-color	Zr	90.6	4.15 amor.	4

THE ELEMENTS (Continued)

No.	Melting point ° C.	Boiling point ° C.	Discovered	Discoverer	Where found
1	940	....	1885	Welsbach	In cerite and other rare minerals.
2	....	....	1903	Mme. Curie	In pitchblende.
3	1950	....	1804	Wollaston	With platinum and iridosmine.
4	38.5	696	1860	Bunsen	In lepidolite and some mineral springs.
5	2400	....	1845	Claus	With platinum and iridosmine.
6	1300–1400	....	1879	Boisbaudran	In samarskite, cerite and other rare minerals.
7	1350	....	1879	Nilson	In gadolinite and other rare minerals.
8	217	690	1817	Berzelius	Mainly as impurity in sulphur.
9	1420	3500	1823	Berzelius	In quartz, most abundant after oxygen.
10	961	1955	Pre	historic	Native and in many ores.
11	97.6	750	1807	Davy	In common salt, sea water and many rocks.
12	900	white heat	1808	Davy	In strontianite and rare minerals.
13	120	444.7	Pre	historic	Native and in many sulphides and sulphates.
14	114.5	444.7	....	....	....
15	119.3	444.7	....	....	....
16	2850	....	1802	Ekeberg	In tantalite and other rare minerals.
17	452	1390	1782	Reichenstein	In several rare minerals.
18	....	....	1843	Mosander	In gadolinite.
19	301.7	1280	1862	Crookes	In pyrites and flue dust of sulphuric acid works.
20	1700	....	1828	Berzelius	In thorite and other rare minerals.
21	....	....	1879	Cleve	In gadolinite.
22	231.9	2270	Pre	historic	In cassiterite (SnO_2).
23	....	....	....	....	....
24	....	....	....	....	....
25	1795	....	1789	Gregor	In rocks and clays in small amounts.
26	3200	....	1781	d'Elhujar	In wolframite.
27	Near Mo	....	1789	Klaproth	In pitchblende and other rare minerals.
28	1720	....	1830	Sefström	In vanadinite and other minerals.
29	−140	−109	1895	Ramsey and Travers	Rare element in air.
30	....	....	....	....	....
31	....	....	1878	Marignac	In gadolinite and other rare minerals.
32	....	....	1828	Wohler	In gadolinite and other rare minerals.
33	419	918	1520	Paracelsus	In ores as oxide, carbonate, sulphide and silicate.
34	2350	....	1824	Berzelius	In zircon and other rare minerals.

PHYSICAL CONSTANTS OF

Compiled from the "Chemiker Kalender,"

	Name.	Formula.	Mol. wt.	Crystalline form and color.
1	Acetic acid	$H.C_2H_3O_2$	60.03	
2	Aluminum	Al	27.1	regular, bluish white
3	Aluminum acetate, normal	$Al(C_2H_3O_2)_3$	204.17	
4	bromide	$Al_2Br_6(+12H_2O)$	534.	colorless
5	carbide	Al_4C_3	144.4	
6	chloride	$Al_2Cl_6(+12H_2O)$	266.9	hexagonal
7	fluoride	Al_2F_6	168.2	
8	hydroxide	$Al_2(OH)_6$	156.3	amorphous, white
9	iodide	$Al_2I_6(+12H_2O)$	815.7	white
10	nitrate	$Al_2(NO_3)_6+15H_2O$	696.7	
11	oxide	Al_2O_3	102.2	hexagonal, amorphous
12	phosphate	$Al_2(PO_4)_2$	244.2	hexagonal, colorless
13	sulphate	$Al_2(SO_4)_3$	342.4	white
14	sulphate	$Al_2(SO_4)_3+18H_2O$	666.7	monoclinic, colorless.
15	sulphide	Al_2S_3	150.4	yellow crystals
16	Ammonia	NH_3	17.	
17	Ammonium acetate	$NH_4(C_2H_3O_2)$	77.07	
18	alum	$Al_2(SO_4)_3.(NH_4)_2SO_4+24H_2O$	907.1	regular, colorless
19	iron, alum	$Fe_2(SO_4)_3.(NH_4)_2SO_4+24H_2O$	964.4	regular, violet
20	bichromate	$(NH_4)_2Cr_2O_7$	252.1	monoclinic, yellow or red
21	carbonate, norm.	$(NH_4)_2CO_3+H_2O$	114.2	colorless
22	carbonate, prim	$NH_4.H.CO_3$	79.1	rhombic, colorless.
23	carbonate-carbamate	$NH_4.H.CO_3+NH_4CO_2.NH_2$	157.1	white
24	chloride	NH_4Cl	53.5	regular or tetragonal colorless
25	chromate	$(NH_4)_2CrO_4$	152.1	monoclinic, yellow
26	cyanate	NH_4CNO	60.1	
27	iodide	NH_4I	144.9	regular
28	magnesium arsenate	$Mg(NH_4)AsO_4+6H_2O$	289.4	tetragonal
29	magnesium phosphate	$Mg(NH_4)PO_4+6H_2O$	245.6	tetragonal
30	nitrate	$(NH_4)NO_3$	80.1	rhombic
31	nitrite	NH_4NO_2	64.1	
32	oxalate	$(NH_4)_2C_2O_4.H_2O$	142.10	trimetric prisms
33	persulphate	$(NH_4)_2S_2O_8$	228.2	monoclinic
34	phosphate, sec	$(NH_4)_2HPO_4$	132.2	monoclinic, colorless.
35	phosphomolybdate.	$(NH_4)_3PO_4+10MoO_3+3H_2O$	1643.3	yellow
36	platinochloride	$(NH_4)_2PtCl_6$	443.7	yellow
37	sulphate	$(NH_4)_2SO_4$	132.2	rhombic, colorless.
38	sulphydrate	$(NH_4)HS$	51.2	rhombic, colorless
39	sulphocyanate	$NH_4.CNS$	76.2	monoclinic, colorless.
40	Antimonic acid	H_3SbO_4	169.2	
41	Antimonous acid	H_3SbO_3	153.2	
42	Antimony	Sb	120.2	rhombohedric, white.
43	Antimony chloride, tri	$SbCl_3$	226.6	rhombic
44	chloride, penta	$SbCl_5$	297.5	

Abbreviations. a., acids; al., alcohol; alk., alkalies; appr., approximately. aq. reg.. aqua regia; atm., atmospheres; conc., concentrated; decomp., decomposes.

INORGANIC COMPOUNDS

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	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 parts of Cold water.	Hot water.	Alcohol, acids, etc.
1	1.0607	17.	118.	s. a. p.	s. a. p.	s. al.
2	2.71	657.	....	....	....	s. alk.; s. HCl, H_2SO_4
3	....	decomp.	....	s.	decomp.	
4	2.54	93.	263.	s.	s.	s. al.
5						
6	....	190.(2½at.)	183.	400.	v. s.	50 al.
7	3.1	....	....	i.	i.	i. al., a., alk.
8	2.3	....	....	i.	i.	s. a., alk.
9	2.63	185.	360.	s.	....	s. al., s. CS_2
10	....	70.	150.	v. s.	....	s. al.
11	3.75–4.0	....	....	i.	i.	s. H_2SO_4.
12	....	....	....	i.	....	s. a., alk
13	2.59	....	....	36.1	89.1	
14	1.62	....	....	107.	11.32	sl. s. al.
15	2.37					
16	0.597 D	−75.	−33.5	1050.	....	s. al.
17	....	89.	....	148.		
18	1.63	....	....	9.	422.	i. al.
19	1.712	230.	....	14.3(20°)	....	i. al.
20	2.367	....	....	v. s.	v. s.	
21	....	....	....	s.	s.	
22	1.586	60.	....	25.	....	i. al.
23	....	....	sublimes	25. (15°)	70. (65°)	
24	1.52	....	....	33.(10°).	73.(100°)	12. (8°)
25	1.866	....	....	v. s.		
26	....	....	....	s.	....	sl. s. al.
27	2.515	....	....	....	v. s.	s. al.
28	....	....	....	0.17	i.	i. al.
29	1.65	....	....	0.005	i.	i. al.
30	1.71	166.	200.	200. (15°)	v. s.	s. al.
31	1.69	....	....	s.		
32	1.502	....	....	4.2	41.34	
33	....	....	....	58.		
34	1.619	....	....	25.	s.	i. al.
35	....	....	....	i.	i.	i. al.
36	3.065	....	....	0.67	1.25	al. 0.05
37	1.77	140.	....	76.(20°)	97 8(100°)	i. al.
38	....	sublimes	....	s.	s.	s. al.
39	1.306(13°)	159.	170.	122. (0°)	162. (20°)	s. al.
40	6.6	decomp.	....	sl. s.	sl. s.	s. a. and KOH
41	....	decomp.	....	i.	i.	i. al.
42	6.715	631.	....	....	....	s. hot H_2SO_4 aq. reg.
43	3.06 (26°)	73.2	220.5	s.	....	s. conc. HCl, al.
44	2.316	−6.				

Abbreviations, (cont.): i., insoluble; s., soluble; s. a. p., soluble in all proportions; sl. s., slightly soluble; subl., sublimes; v. s., very soluble; vol., volumes.

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
45	Antimony hydride	SbH_3	123.2	......
46	oxide tri-	Sb_2O_3	288.4	rhombic
47	oxide, tetr-	Sb_2O_4	304.4	white
48	oxide, pent-	Sb_2O_5	320.4	yellow
49	Antimony oxychloride (ous)	$SbOCl$	171.7	regular, white
50	oxychloride (ic)	$SbOCl_3$	242.6	yellow
51	sulphate	$(SbO)_2SO_4$	368.1	......
52	sulphide, tri-	Sb_2S_3	336.6	(*a*) hexagonal, black (*b*) amorphous, brown
53	sulphide, penta-	Sb_2S_5	400.8	orange
54	Arsenic (cryst.)	As_4	299.8	gray
55	Arsenic acid, ortho-	$AsO(OH)_3+\frac{1}{2}H_2O$	151.	......
56	Arsenic acid, pyro-	$As_2O_3(OH)_4$	266.	......
57	Arsenic acid, meta-	$AsO_2.OH$	124.	......
58	Arsenic pentoxide	As_2O_5	230.	amorphous
59	disulphide	As_2S_2	214.1	monoclinic, red
60	pentasulphide	As_2S_5	310.3	yellow
61	Arsenous chloride	$AsCl_3$	181.3	......
62	hydride	AsH_3	78.	......
63	trioxide	As_2O_3	197.9	reg. amorphous, white
64	oxychloride	$AsOCl$	126.4	brown
65	selenide	As_2Se_3	386.5	......
66	sulphide	As_2S_3	246.1	monoclinic, yellow
67	Barium	Ba	137.4	white
68	acetate	$Ba(C_2H_3O_2)_2.H_2O$	273.43	prisms
69	bromide	$BaBr_2+2H_2O$	333.2	rhombic
70	carbonate	$BaCO_3$	197.4	rhombic, white
71	chlorate	$Ba(ClO_3)_2+H_2O$	322.3	monoclinic
72	chloride	$BaCl_2(+2H_2O)$	244.3	rhombic
73	chromate	$BaCrO_4$	253 5	yellow
74	fluoride	BaF_2	175.4	amorphous, white
75	hydroxide	$Ba(OH)_2+8H_2O$	315.6	tetragonal, white
76	nitrate	$Ba(NO_3)_2$	261.5	regular
77	nitrite	$Ba(NO_2)_2$	229.5	hexagonal
78	oxide	BaO	153.4	regular, amorphous, gray
79	perchlorate	$Ba(ClO_4)_2$	336.3	hexagonal
80	phosphate, prim	$BaH_4(PO_4)_2$	331.4	triclinic
81	phosphate, tert	$Ba_3(PO_4)_2$	602.2	......
82	phosphate, sec	$BaHPO_4$	233.4	......
83	pyrophosphate	$Ba_2P_2O_7$	448.8	rhombic, white
84	silicofluoride	$BaSiF_6$	279.8	......
85	sulphate	$BaSO_4$	233.5	rhombic
86	sulphide	BaS	169.5	rhombic
87	superoxide	BaO_2	169.4	gray
88	Bismuth	Bi	208.0	rhombohedric
89	Bismuth chloride	$BiCl_3$	314.5	white crystals
90	hydroxide	$Bi(OH)_3$	259.0	white
91	nitrate	$Bi(NO_3)_3+5H_2O$	484.1	triclinic
92	pentoxide	Bi_2O_5	496.	brown
93	sulphate	$Bi_2(SO_4)_3$	704.2	white
94	trioxide	Bi_2O_3	464.	yellow
95	trisulphide	Bi_2S_3	512.2	rhombic

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D, air 1	Melting point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 parts of Cold water.	Hot water.	Alcohol, acids, etc.
45	4.3 D	-91.5	-18.	20. vol.	4.	al. 1500 vol.
46	5.6	...	sublimes	i.	...	s. conc. HCl acetic acid
47	4.07	...	...	i.	i.	s. alk., sl. s. a.
48	6.52	300.	...	sl. s.	i.	s. HCl; s. KOH
49	...	decomp.	decomp.	i.	...	i. al.; s. HCl, CS_2
50	...	...	...	...	...	s. al.
51	4.89	...	...	decomp.	decomp.	
52	(*a*) 4.62 (*b*) 4.15	555.	...	i.	i.	s. NH_4. SH
53	...	...	...	i.	i.	s. NH_4.SH; s. alk.
54	5.73	450 subl.	860.	i.	i.	i.
55	2.0-2.5	180.	...	16.7	50.	s. alk.
56	...	206 decomp.				
57						
58	3.39	...	decomp.	150.	v. s.	v. s.
59	3.54	-8.	...	i.	i.	s. K_2S
60	...	...	subl.	i.	i.	s. al.
61	2.205	-29.	134	s.	decomp.	s. HCl, s. al.
62	2.7 D	-119.	-55.	5. 1 vol.	sl. s.	sl. s. alk.
63	3.69	218. subl.	...	3.	9.5	s. HCl
64	...	...	...	decomp.	decomp.	...
65	4.75	360.	...	i.	decomp.	s. alk.
66	3.46	...	700.	i.	i.	s. al.
67	3.6	850.	1000.	decomp.	decomp.	
68	2.02	decomp.	...	62.9	80.5	i. al.
69	3.69	880.	...	100.	204.	s. al.
70	4.275	795.	...	i.	i.	i. al.
71	3.179	414.	120.	25.	52.	sl. s. al.
72	3.05	960.	...	41.5 (10°)	77. (100°)	i. al.; sl. s. HCl, HNO_3
73	3.9	...	...	i.	i.	s. a.
74	4.58	1280.	...	sl. s.	...	s. NH_4Cl, HF
75	1.656	78.	103.	5. (16°)	3875.	sl. s. al.
76	3.2	593.	...	5.2 (0°)	34.8	i. al.
77	...	115 decomp.	...	63. (20°)	...	v. s. HCl; s. alk.
78	5.5					
79	...	505.	...	s.	...	s. alk.
80	2.9 (4°)	...	...	decomp.	decomp.	s. a.
81	4.1	...	...	i.	i.	s. a.
82	...	...	...	i.	i.	s. a.; s. NH_4Cl
83	3.9 (20°)	...	...	sl. s.	sl. s.	s. a.
84	4.28 (21°)	...	...	0.026	sl. s.	i. al.; sl. s. a.
85	4.486-4.53	1500.	...	i.	i.	sl. s. H_2SO_4
86	4.30	...	...	decomp.	decomp.	i. al.
87	4.958	...	...	i.	decomp.	s. HCl
88	9.7	268.	1435.	i.	...	s. HNO_3
89	4.48	230.	429.	decomp.	decomp.	
90	...	100.	...	i.	...	s. a.
91	...	73.	80.	decomp.	decomp.	s. HNO_3
92	...	225 decomp.	...	i.	...	s. HCl
93	...	...	...	decomp.		
94	8.868	...	...	i.	...	s. alk.
95	6.5	decomp.	...	i.	...	s. HNO_3

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
96	Beryllium, glucinum	Be	9.1	white
97	Beryllium chloride	$BeCl_2(+4H_2O)$	152.1	colorless crystals
98	nitrate	$Be(NO_3)_2+3H_2O$	187.2	
99	oxide	BeO	25.1	amorphous, white
100	sulphate	$BeSO_4+4H_2O$	177.2	tetragonal, $7H_2O$, monoclinic.
101	Boric acid	H_3BO_3	62.	triclinic
102	Boron	B	11.	monoclinic, yellow; amorphous, brown
103	Boron chloride	BCl_3	117.4	
104	oxide	B_2O_3	70.	
105	sulphide	B_2S_3	118.2	white
106	Bromic acid	$HBrO_3$	129.	colorless
107	Bromine	Br_2	159.8	brown
108	Bromine chloride	$BrCl+10H_2O$	295.6	yellow
109	iodide	BrI	206.8	
110	Cadmium	Cd	112.4	hexagonal
111	Cadmium carbonate	$CdCO_3$	172.4	
112	chloride	$CdCl_2+2H_2O$	219.3	
113	fluoride	CdF_2	150.4	
114	hydroxide	$Cd(OH)_2$	146.4	white
115	nitrate	$Cd(NO_3)_2+4H_2O$	308.6	
116	oxide	CdO	128.4	regular, brown
117	sulphate	(*a*) $3CdSO_4+8H_2O$	769.5	monoclinic
		(*b*) $CdSO_4+4H_2O$	280.6	
118	sulphide	CdS	144.5	hexagonal, yellow
119	Caesium chloride	CsCl	168.3	regular, colorless
120	hydroxide	CsOH	150.	
121	nitrate	$CsNO_3$	195.	tetragonal
122	sulphate	$CsSO_4$	362.1	colorless
123	Calcium	Ca	40.00	rhombohedric, yellow
124	Calcium bromide	$CaBr_2(+6H_2O)$	199.9	white
125	carbide	CaC_2	64.	gray crystals
126	carbonate	$CaCO_3$	100.	rhombohedric and rhombic.
127	chloride	$CaCl_2+6H_2O$	219.	hexagonal
128	chromate	$CaCrO_4+2H_2O$	192.	yellow crystals
129	fluoride	CaF_2	78.	regular
130	hydroxide	$Ca(OH)_2$	74.	
131	hypochlorite	$Ca(OCl)_2+4H_2O$	215.	
132	hypophosphite	$Ca(H_2PO_2)_2$	170.	monoclinic
133	metaphosphate	$Ca(PO_3)_2$	198.	white
134	nitrate	$Ca(NO_3)_2+4H_2O$	236.2	monoclinic
135	oxide	CaO	56.	amorphous, regular
136	phosphate, prim.	$CaH_4(PO_4)_2+H_2O$	252.1	rhombic
137	phosphate, sec.	$CaHPO_4+2H_2O$	172.1	
138	phosphate, tert.	$Ca_3(PO_4)_2$	310.	
139	pyrophosphate	$Ca_2P_2O_7$	254.	white
140	sulphate	$CaSO_4+2H_2O$	172.1	monoclinic
141	sulphide	CaS	72.	regular, white
142	Carbon, diamond	C	12.	regular, colorless
143	Carbon, graphite	C	12.	hexagonal, gray
144	Carbon dioxide	CO_2	44.	
145	disulphide	CS_2	76.1	
146	monoxide	CO	28.	
147	tetrachloride	CCl_4	153.8	
148	Cerium	Ce	140.3	
149	carbonate	$Ce_2(CO_3)_3+5H_2O$	550.4	

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 parts of Cold water.	Hot water.	Alcohol, acids, etc.
96	2.1	1000 appr.	....	i.	i.	s. HCl.; s. alk.
97	....	600.	sublimes	....	v. s.	s. al.
98	....	60.	200 decomp			
99	3.02	....	....	i.	....	s. alk.
100	1.725	....	....	100. (15°)		
101	1.43	185.	....	4.	34.	s. al.
102	2.68	....	....	i.	1.	i. al.
103	1.35	....	18.2	decomp.		
104	1.83 (4°)	1300.	....	3.	....	s. al.
105	1.55	310.	....	decomp.	....	decomp.
106	....	....	100.			
107	3.187	−7.3	63.	3.5		
108	....	7. anhy	....	v. s.		
109	....	36.	....	....	....	s. CS_2, $CHCl_3$
110	8.55–8.67	315.	860.	....	....	s. HNO_3, HCl
111	4.49	....	....	i.	i.	s. a.
112	3.32	....	....	140.	150.	s. al.
113	5.99	520.	....	sl. s.	sl. s.	s. HCl
114	4.79	300.	....	i.	i.	s. a.
115	2.955	60.	132.	143.4	....	s. al.
116	6.9–8.1	....	....	i.	i.	
117	(*a*)	....	....	....	v. s.	
	(*b*) 3.05	....	....	....	v. s.	i. al.
118	4.58	white heat	....	i.	i.	s. conc. a.
119	....	red heat	sublimes	....	v. s.	
120	4.018	....	....	s.	s.	s. al.
121	....	....	....	10.6(3°.2)	v. s.	sl. s. al.
122	....	....	....	s.	v. s.	i. al.
123	1.55	800.	....	decomp.	decomp.	decomp.
124	3.32	765.	....	v. s.	v. s.	
125	2.3	....	....	decomp.		
126	2.9–2.72	decomp. at	red heat	0.0018	0.088	s. water cont CO_2
127	1.64	29.	200.	400.	650.	al. 13
128	....	red heat	....	22.2 (0°)	s.	
129	3.18	1330.	....	0.05	sl. s.	
130	2.078	....	....	0.137 (15°)	0.075 (100°)	i. al.
131	....	....	....	s.		
132	....	decomp. at	red heat	....	s.	i. al.
133	....	....	....	i.	i.	i. al.
134	1.9 (15°)	....	132 decomp.	....	v. s.	s. al.
135	3.3	....	....	decomp.	decomp.	s. water cont. CO_2
136	2. (4°)	100.	200 decomp.	0.1285	0.0787	s. a.
137	2.3	....	....	sl. s.	decomp.	
138	3.18	....	....	i.	i.	s. a.
139	....	....	....	i.		s. a.
140	2.32	red heat	....	0.241 (0°)	0.222 (100°)	i. al.
141	2.8	....	....	decom.		
142	2.2	....	....	i.	i.	i.
143	....	....	....	i.	i.	i.
144	1.524 D	−79.	....	1:1 vol.	....	al. 1:3.3 vol. (15)
145	1.292	−116.	46.	2:1000 (0°)	....	s. al. all prop.
146	0.967 D	−207.	−190.	30. vol.		
147	1.629	fluid	77.			
148	6.6	....	....	decomp.	....	s. HCl, HNO_3
149	....	....	....	i.	....	s. $(NH_4)_2CO_3$

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
150	Cerium chloride	$CeCl_3$	246.6	colorless
151	dioxide	CeO_2	172.3	white powder
152	oxide	Ce_2O_3	328.5	gray powder
153	Chloric acid	$HClO_3(+7H_2O)$	210.6	
154	Chlorine	Cl_2	70.9	green
155	Chlorine dioxide	ClO_2	67.5	red
156	monoxide	Cl_2O	86.9	yellowish red
157	Chromium	Cr	52.1	rhombohedric, gray
158	Chromium chloride (ic)	Cr_2Cl_6	316.9	bright red
159	chloride (ous)	$CrCl_2$	123.	white
160	hydroxide (ic)	$Cr_2(OH)_6+4H_2O$	278.3	blue
161	nitrate (ic)	$Cr(NO_3)_3+9H_2O$	400.4	triclinic, bright red.
162	oxide (ic)	Cr_2O_3	152.2	hexagonal, green
163	sulphate (ic)	$Cr_2(SO_4)_3+18H_2O$	716.7	regular, violet
164	sulphide (ic)	Cr_2S_3	200.6	
165	trioxide	CrO_3	100.1	rhombic, red
166	Cobalt	Co	59.	
167	Cobaltic chloride	Co_2Cl_6	220.7	
168	hydroxide	$Co_2(OH)_6$	220.1	black
169	oxide	Co_2O_3	166.	brown
170	Cobalto-cobaltic oxide	Co_3O_4	123.	regular, black
171	Cobaltous carbonate	$CoCO_3$	119.	rhombohedric, red
172	chloride	$CoCl_2+6H_2O$	238.	monoclinic, red
173	cyanide	$Co(CN)_2+3H_2O$	165.1	
174	hydroxide	$Co(OH)_2$	93.	rose
175	nitrate	$Co(NO_3)_2+6H_2O$	291.2	monoclinic, red
176	oxide	CoO	75.	brown
177	phosphate	$Co_3(PO_4)_2+8H_2O$	511.2	
178	sulphate	$CoSO_4+7H_2O$	281.2	rhombic, red
179	sulphide	CoS	91.1	gray
180	Copper	Cu	63.6	regular, red
181	Copper-ammonium sulphate.	$CuSO_4+4NH_3+H_2O$	246.	rhombic, blue
182	nitrate	$Cu(NO_3)_2+6H_2O$	295.8	blue crystals
183	sulphate	$CuSO_4+5H_2O$	249.7	triclinic, blue
184	Cupric acetate	$Cu(C_2H_3O_2)_2H_2O$	199.63	green
185	bromide	$CuBr_2$	223.5	black
186	chloride	$CuCl_2+2H_2O$	170.5	rhombic, blue
187	hydroxide	$Cu(OH)_2$	97.6	blue
188	oxalate	$CuC_2O_4.\frac{1}{2}H_2O$	160.58	bluish white
189	oxide	CuO	79.6	regular and monoclinic, black.
190	phosphate	$Cu_3(PO_4)_2+3H_2O$	434.9	rhombic, blue
191	sulphide	CuS	95.7	hexagonal, black
192	Cuprous bromide	Cu_2Br_2	287.1	brown
193	chloride	Cu_2Cl_2	198.1	white
194	cyanide	$Cu_2(CN)_2$	179.3	white
195	oxide, monohydrate	$4Cu_2O+H_2O$	590.8	yellow
196	oxide	Cu_2O	143.2	regular, red
197	sulphide	Cu_2S	159.3	rhombic, black
198	Ferric acetate, bas.	$FeOH(C_2H_3O_2)_2$	190.9	amorphous
199	chloride	Fe_2Cl_6	324.7	hexagonal, brown or black

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 Parts of		
				Cold water.	Hot water.	Alcohol, acids, etc.
150	....	....	....	s.		
151	6.739	....	....	....	....	s. H_2SO_4
152	6.9-7.0	....	....	....	....	s. conc. H_2SO_4. i. HCl
153	1.282	decomp.	decomp.	s.		
154	2.4502 D	−102.	−33.5	1:2.6 vol.	1:1.4, (40°)	
155	1.5	− 76.	10.			
156	....	explodes	−19.	s.		
157	6.8	....	....	i.	i.	
158	2.36	....	subl. at white heat		i.	i. al.
159	2.75	....	....	s.	s.	
160	....	100.	....	i.	i.	s. a.; s. alk.
161	....	36.5	....	....	....	s. alk.
162	5.21	white heat	....	i.	i.	i. al.
163	1.7 (22°)	....	....	s.	s.	
164	3.77	....	....	....	....	s. HNO_3
165	2.74	190.	decomp.	v. s.	v. s.	decom. with al.
166	8.951	1505	....	i.	i.	s. a.
167	....	decomp.	....	s.		
168	....	....	....	i.	i.	i. al.
169	5.1	decomp. at	red heat	i.	i.	i. al.; s. a.
170	5.8-6.3	....	....	i.	i.	s. conc. H_2SO_4
171	....	....	....	i.	i.	
172	1.84	86.75	110.	s.	s.	
173	....	250.	....	i.	....	s. KCN
174	3.507	....	....	i.	i.	sl. s. ammonia
175	1.83	decomp. at	red heat	....	v. s.	al. 200
176	5.68	decomp.	100.	i.	i.	i. al.
177	....	....	....	i.	i.	i. al.
178	1.924	....	....	4.	65. (70°)	i. al.
179	....	....	....	....	....	s. a.
180	8.85-8.94	1083.	....	i.	i.	s. a.
181	....	150. decomp	....	60.	decomp.	i. al.
182	2.047	38.	decomp.	v. s.	v. s.	v. s.
183	2.274	240.	decomp. red heat	40.	203.	i. al.
184	1.9	240. decomp	....	7.2	20.	al. 7.14; s. ether
185	....	decomp.				
186	2.47	100.	decomp. red heat	60.	v. s.	s. al.
187	3.368	decomp.	....	....	....	s. NH_3
188	....	....	....	i.		
189	6.304	....	....	i.	i.	i. al.
190	....	....	....	sl. s.	decomp.	s. a.
191	4.59	....	....	i.	i.	i. al.
192	4.72	504.	....	i.	....	s. NH_3
193	3.7	440.	....	sl. s.	....	s. HCl; s. NH_3
194	....	red heat	....	....	....	s. HCl, hot H_2SO_4
195	....	360 decomp.	....	....	....	s. NH_3
196	5.8	....	....	i.	i.	s. ammonia
197	5.58	....	....	i.	i.	i. al.
198	....	....	....	i.		s. al., a.
199	2.804	....	283.	158.	....	v. s. al.

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
200	hydroxide	$Fe_2(OH)_6$	214.1	red or brown
201	oxalate	$Fe_2(C_2O_4)_3$	375.7	amorphous
202	oxide	Fe_2O_3	160.	rhombohedric, gray
203	nitrate	$Fe_2(NO_3)_6+18H_2O$	808.6	monoclinic
204	phosphate	$Fe_2(PO_4)_2+4H_2O$	374.1	yellow
205	sulphate	$Fe_2(SO_4)_3+9H_2O$	562.4	rhombic
206	sulphide	Fe_2S_3	207.7	yellow
207	sulphocyanate	$Fe_2(CNS)_6+6H_2O$	568.7	regular, red or black
208	Ferrosoferric oxide	Fe_3O_4	232.	regular, black
209	Ferrous ammonium sulphate.	$FeSO_4, (NH_4)_2SO_4+6H_2O$	392.4	monoclinic
210	carbonate	$FeCO_3$	116.	rhombohedric
211	chloride	$FeCl_2+4H_2O$	199.	monoclinic
212	ferricyanide	$(Fe_2)_2[Fe(CN)_6]_3$	860.7	blue
213	hydroxide	$Fe(OH)_2$	90.	white
214	nitrate	$Fe(NO_3)_2+6H_2O$	288.2	
215	oxide	FeO	72.	black
216	phosphate	$Fe_3(PO_4)_2+8H_2O$	502.2	monoclinic, blue
217	sulphate	$FeSO_4+7H_2O$	278.2	blue green, monoclinic
218	sulphide	FeS	88.1	black
219	Fluorine	F_2	38.	green, yellow
220	Gold	Au	197.2	regular, yellow
221	Gold bromide (ous)	$AuBr$	277.2	green
222	chloride, auric	$AuCl_3$	339.6	yellow, red
223	chloride, aurous	$AuCl$	232.7	yellow
224	cyanide, auric	$Au(CN)_3+6H_2O$	383.4	
225	cyanide, aurous	$AuCN$	223.2	yellow
226	hydroxide, auric	$Au(OH)_3$	248.2	yellow, brown
227	hydroxide, aurous	$Au(OH)$	214.2	red, brown
228	oxide, auric	Au_2O_3	442.4	black
229	oxide, aurous	Au_2O	410.4	brown, black
230	Helium	He	4.	
231	Hydrobromic acid	HBr	81.	
232	Hydrochloric acid	HCl	36.5	
233	Hydrocyanic acid	HCN	27.1	
234	Hydrofluoric acid	HF	20.	
235	Hydriodic acid	HI	127.9	
236	Hydrogen	H_2	2.016	
237	Hydrogen peroxide	H_2O_2	34.	colorless, blue
238	sulphide	H_2S	34.1	
239	Iodic acid	HIO_3	175.9	rhombic
240	Iodine	I_2	253.8	black
241	Iodine chloride	ICl	162.3	red
242	trichloride	ICl_3	233.2	yellow crystals
243	Iron, cast	Fe	56.	gray
244	wrought	Fe	56.	gray
245	steel	Fe	56.	gray
246	Iron carbide	FeC_4	104.	gray crystals
247	Lead	Pb	206.9	gray, regular, white
248	Lead acetate	$Pb(C_2H_3O_2)_2.3H_2O$	379.2	monoclinic
249	bromide	$PbBr_2$	366.8	colorless
250	carbonate	$PbCO_3$	266.9	rhombic
251	chloride	$PbCl_2$	277.8	rhombic
252	chromate	$PbCrO_4$	323.	monoclinic, yellow
253	hydroxide	$Pb(OH)_2$	240.9	
254	iodide	PbI_2	460.6	yellow crystals
255	nitrate	$Pb(NO_3)_2$	331.	regular

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 parts of Cold water.	Hot water.	Alcohol, acids, etc.
200	3.4–3.9	....	....	i.	i.	i. al.
201	....	100 decomp.	....	v. s.	....	i. al.
202	5.2–5.3	....	....	i.	i.	s. a.
203	1.6835	47.2	decomp.	s.	s.	s. al.
204	2.87	....	....	i.	i.	s. a.
205	2.–2.1	....	....	decomp.	decomp.	decomp. by al.
206	....	decomp.				
207	....	....	....	s.	v. s.	s. al.; s. ether
208	5.18	....	....	i.	i.	i. al.
209	1.813	....	....	17.	v. s.	i. al.
210	3.7–3.9	....	....	i.	i.	s. water cont. CO_2
211	1.926	red heat	1400.	130.	v. s.	s. al.
212	....	decomp.	....	i.	....	dec. by alk.
213	....	....	....	sl. s.		
214	....	....	....	s.	decomp.	....
215	....	....	....	i.	i.	s. a.
216	2.58–2.68	....	....	i.	i.	s. a.
217	1.889	280.	decomp. red heat	60.	333.	i. al.
218	4.84	red heat	....	i.	i.	s.a.
219	1.31 D	−233.	−187.	decomp.		
220	19.26–19.55	10.64	....	....	....	s. aq. reg.
221	....	150.	....	i.	....	decomp. by a.
222	3.9	subl.	150.	....	s.	s. al.
223	....	decomp.	....	decomp.	decomp.	
224	....	....	....	v.s.	v. s.	s. al.
225	....	decomp.	....	i.	i.	i. al.
226	....	decomp.	....	i.	i.	s. HNO_3
227	....	250 decomp.	....	s.		
228	....	100 decomp.	....	i.	i.	s. HCl
229	....	250 decomp.	....	i.	i.	s. HCl
230	0.137 D	−253.				
231	2.79 D	−87.	−68.	v. s.	s.	s. al.
232	0.908 D (0°)	−112.5	−83.	82.5 (0°)	56. (60°)	327 vol. in al.
233	0.6967	−13.8	26.54	s. a. p.	s. a. p.	s. a. p. al.
234	0.9879	−102.	19.4	v. s.	v. s.	
235	4.38 D	−55.	−36.7	v. s.	s.	s. al.
236	0.0000896	−257.	−253.	1.93 vol.		
237	1.499	−2.	84.	s. a. p.	....	s. ether
238	1.178 D	−85.	−61.8	437. v. (0°)	3.23 v. (15°)	
239	4.629	170 decomp.	....	187.	v. s.	
240	4.958	114.	184.	sl. s.	sl. s.	s. al.
241	3.2	25.	101.	v. s. decom.	....	s. HCl
242	3.11	25 decomp.	....	s. decomp.		
243	7.–7.6	1050.	....	i.	i.	s. a.
244	7.25–7.79	1545.	....	i.	i.	s. a.
245	7.6–7.8	1300.	....	i.	i.	s. a.
246	7.07	....	....	i.	i.	s. a.
247	11.35–11.28	327.	1470.	i.	....	s. HNO_3
248	2.50	75.	280.	45.64	200.	i. al.
249	6.611	....	....	sl. s.	s.	i. al.
250	6.465	....	....	0.00198	i.	i.al.
251	5.802	485.	900.	0.74	5.	s. al.
252	6.29	....	....	i.	i.	s .alk.; sl. s. a.
253	....	145.	....	sl. s.	sl. s.	s. alk.
254	6.07	375.–383.	861.–954.	0.081	0.515	i. al.; s. KI
255	4.58	decomp.	....	48. (10°)	139. (100°)	s. alk.

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
256	Lead oxalate	PbC_2O_4	294.9	
257	oxide	(*a*) PbO	222.9	rhombic, yellow
258	oxide	(*b*) PbO	222.9	hexagonal, red
259	oxychloride	$PbCl_2.PbO$	500.7	tetragonal
260	phosphate	$Pb_3(PO_4)_2$	810.7	white
261	sesquioxide	Pb_2O_3	461.8	amorphous, yellow
262	suboxide	Pb_2O	429.8	black
263	sulphate	$PbSO_4$	303.	rhombic
264	sulphide	PbS	239.	regular
265	Lithium	Li	7.	
266	Lithium carbonate	Li_2CO_3	74.1	white
267	chloride	$LiCl+2H_2O$	78.5	tetragonal
268	hydroxide	$LiOH$	24.	
269	nitrate	$LiNO_3$	69.1	rhombohedric
270	oxide	Li_2O	30.	white
271	Magnesium	Mg	24.4	white
272	Magnesium bromide	$MgBr_2+6H_2O$	292.4	hexagonal
273	carbonate	$MgCO_3$	84.4	rhombohedric and rhombic.
274	chloride	$MgCl_2+6H_2O$	203.4	monoclinic
275	hydroxide	$Mg(OH)_2$	58.4	rhombohedric
276	nitrate	$Mg(NO_3)_2+6H_2O$	256.6	monoclinic, triclinic
277	oxide	MgO	40.4	regular
278	phosphate	$MgHPO_4+7H_2O$	246.5	hexagonal
279	pyrophosphate	$Mg_2P_2O_7+3H_2O$	276.8	
280	sulphate	$MgSO_4+7H_2O$	246.6	rhombic and monoclinic.
281	sulphide	MgS	56.4	brown
282	Manganese	Mn	55.	gray
283	carbonate	$MnCO_3$	115.	rhombohedric, white
284	chloride	$MnCl_2+4H_2O$	198.	monoclinic, bright red.
285	dioxide	MnO_2	87.	rhombic, gray
286	heptoxide	Mn_2O_7	222.	black
287	hydroxide (ic)	$Mn_2O_2(OH)_2$	176.	tetragonal, black or brown.
288	hydroxide (ous)	$Mn(OH)_2$	89.	white
289	nitrate	$Mn(NO_3)_2+6H_2O$	287.2	monoclinic, white
290	oxide (ic)	Mn_2O_3	158.	tetragonal
291	Mercuric chloride	$HgCl_2$	271.5	rhombic
292	cyanide	$Hg(CN)_2$	252.6	tetragonal
293	oxide	HgO	216.6	red
294	nitrate	$Hg(NO_3)_2$	324.6	
295	sulphate	$HgSO_4$	296.7	white
296	sulphate, basic	$HgSO_4+2HgO$	729.9	yellow
297	sulphide	HgS	232.4	rhombohedric, red amorphous, black
298	Mercurous carbonate	Hg_2CO_3	461.2	yellow
299	chloride	Hg_2Cl_2	472.1	rhombic, white
300	chromate	Hg_2CrO_4	517.2	red
301	oxide	Hg_2O	417.2	black
302	nitrate	$Hg_2(NO_3)_2$	252.2	monoclinic
303	sulphate	Hg_2SO_4	497.3	monoclinic
304	Mercury	Hg	200.6	white
305	Molybdenum	Mo	96.	white
306	chloride (ic)	$MoCl_5$	273.3	black
307	chloride (ous)	$MoCl_2$	166.9	yellow
308	disulphide	MoS_2	160.6	black powder

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 Parts of Cold water.	Hot water.	Alcohol, acids, etc.
256	5.025	300. decomp.	....	0.00018	....	i. al.; s. HNO_3
257	9.29	red heat	....	i.	i.	s. alk.
258	8.74–9.	....	....	i.	i.	
259	7.21					
260	5.8	....	....	....	....	s. alk., HNO_3
261	....	decomp.	....	i.	i.	i. alk.
262	....	decomp.	....	decomp.	decomp.	decomp. by alk.
263	6.2–6.38	red heat	....	sl. s.	sl. s.	i. al.; s. alk.
264	7.25–7.7	red heat	sublimes	i.	i.	i. al.
265	0.59	186.	950.	decomp.	decomp.	decomp. by al.
266	2.11	red heat	....	0.769 (13°)	0.78	i. al.
267	2.036	decomp.	white heat	65.	125.	v. s. al.
268	....	red heat	....	sl. s.		
269	2.39	....	....	48.	227.	v. s. al.
270	....	....	....	s.	s.	
271	1.743	750.	1100.	i.	....	s. a.
272	....	165.	....	v. s.		
273	2.9–3.1	decomp.	....	....	....	s water cont. CO_2
274	1.558	decomp.	....	365.	558.6	al. 50
275	2.34	decomp.	....	i.	i.	s. NH_4Cl
276	....	90.		200.	....	s. al.
277	3.07–3.65	....	....	0.001	....	s. a.
278	....	100.	....	sl. s.	....	s. a.
279	2.53	....	....	i.	i.	i. al.
280	1.685	250.	....	76.9 (0°)	671.	s. al.
281	2.2–2.8	....	....	....	decomp.	
282	7.2	1900.	....	decomp. sl.	decomp.	s. a.
283	3.5	....	....	i.	i.	i. al.
284	1.913	87.6	....	150.	650.	al. 53
285	4.7–5.02	390. decomp.	....	i.	i.	
286	....	....	70. decomp.	s. decomp.	....	s. H_2SO_4
287	4.33	....	....	i.	i.	
288	3.26	....	....	i.	i.	s. a.
289	1.8	87.5	130.	v. s.	v. s.	s. al.
290	4.32	....	....	i.	i.	
291	5.42	260.–270.	300.	7.4 (20°)	54.	al. 33; ether 25
292	3.77	decomp.	....	12.	53.	al. 5
293	11.136	decomp.	at red heat	sl. s.	sl. s.	i. al.
294	....	decomp.	at red heat	decomp.	to basic salt	s. HNO_3
295	....	....	....	decomp.	to basic salt	i. al.
296	6.444	....	....	1: 2000	1: 600	i. al.
297	8.124	....	sublimes	i.	i.	s. aq. reg.
298	3.92	130. decomp.	....	i.	i.	i. al.
299	6.56	....	....	i.	i.	i. al.
300	....	decomp.	....	i.	i.	i. al.
301	8.95	decomp.	....	i.	i.	i. al.
302	....	decomp.	....	s.		
303	....	....	....	sl. s.	decomp.	s. hot H_2SO_4
304	13.59	−39.38	357.3	i.	i.	s. HNO_3, H_2SO_4
305	9.01	white heat	....	....	....	s. HNO_3; i. HCl
306	....	194.	268.	decomp.		
307	....	sublimes	....	i.	i.	s. al. HCl
308	5.06					

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
309	Molybdenum oxide..	MoO_2	128.	tetragonal, brown..
310	phosphoric acid...	$H_3PO_4.12MoO_3+12H_2O$	2042.	monoclinic, yellow.
311	tetrasulphide.....	MoS_4	224.2	brown
312	trioxide	MoO_3	141.	white
313	Molybdic acid	$H_2MoO_4+H_2O$	180.	yellow
314	Nickel	Ni	58.7	
315	Nickel chloride	$NiCl_2$	129.6	yellow
316	chloride	$NiCl_2+6H_2O$	237.7	hexagonal
317	hydroxide (ic)	$Ni_2(OH)_6$	219.5	black
318	hydroxide (ous)	$Ni(OH)_2$	92.7	green
319	nitrate	$Ni(NO_3)_2+6H_2O$	290.9	monoclinic, green..
320	oxide (mon-)	NiO	74.7	regular, green
321	sesquioxide	Ni_2O_3	165.4	black
322	sulphate	$NiSO_4$	154.8	yellow
323	sulphate	$NiSO_4+6H_2O$	262.9	tetragonal, blue; monoclinic, green
324	sulphate	$NiSO_4+7H_2O$	280.9	rhombic, green
325	sulphide	NiS	90.75	hexagonal, black
326	Nitric acid	HNO_3	63.02	
327	Nitrogen	N_2	28.02	
328	Nitrogen dioxide	(*a*) N_2O_4	92.1	
329	dioxide	(*b*) NO_2	46.	
330	oxide (nitric)	NO	30.	
331	oxide (nitrous)	N_2O	44.1	
332	pentasulphide	N_2S_5	187.	red
333	tetrasulphide	N_4S_4	183.	red
334	Osmium	Os	191.	regular, white
335	Osmium chloride	$OsCl_4$	332.8	red
336	tetroxide	OsO_4	255.	monoclinic, colorless
337	oxide	OsO	207.	black
338	Oxalic acid	$H_2C_2O_4.2H_2O$	126.1	crystals
339	Oxygen	O_2	32.	
340	Ozone	O_3	48.	
341	Palladium	Pd	106.7	white
342	Palladium chloride..	$PdCl_2+2H_2O$	213.7	black, red
343	Perchloric acid	$HClO_4$	100.5	
344	Periodic acid, ortho.	H_5IO_6	227.9	
345	Phosphoric acid, meta-	HPO_3	80.	
346	ortho–	H_3PO_4	98.	
347	pyro–	$H_4P_2O_7$	178.	
348	Phosphorus, white...	P_4	124.2	regular, colorless...
349	Phosphorus, red	P_4	124.2	amorphous, red brown
350	Phosphorus, black...	P_4	124.2	rhombohedric
351	Phosphorous acid...	H_3PO_3	82.	colorless crystals...
352	Phosphorous chloride (ic)	PCl_5	208.3	yellow crystals
353	chloride (ous)	PCl_3	137.4	colorless
354	pentasulphide	P_2S_5	222.3	yellow
355	pentoxide	P_2O_5	142.	white, amorphous..
356	trioxide	P_2O_3	110.	amorphous, white..
357	hydride, phosphine	PH_3	34.	
358	hydride, fluid	P_2H_4	66.	
359	hydride, solid	P_4H_2	126.	yellow
360	Platinic acid, chlor-.	H_2PtCl_6	409.5	red crystals
361	Platinic chloride	$PtCl_4+5H_2O$	426.7	monoclinic, red

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 Parts of Cold water.	Hot water.	Alcohol, acids, etc.
309	6.44	....	....	i.	i.	i.
310	....	104.	....	s.		
311	....	....	....	i.	....	s. K_2S
312	4.39	red heat	sublimes	0.2	0.104	s. NH_3
313	....	....	....	s.	s.	s. a.
314	8.57–8.8	1484.	....	....	....	s. a.
315	2.56	sublimes	....	s.	s.	s.
316	....	....	....	s.	s.	s.
317	....	....	....	i.	i.	s.a.; s. NH_3
318	4.36	....	....	i.	i.	s. NH_3; s. a.
319	2.065	56.7	136.7	50.	v. s.	s. al.
320	6.4–6.7	....	....	i.	....	s. NH_3
321	4.846	decomp.	....	....	....	s. HCl
322	3.418	....	....	37.4	62. (70°)	i. al.
323	2.031	280.	....	s.	s.	s. NH_3
324	1.931	103.	....	106. (20°)	226. (70°)	
325	....	....	....	i.	....	sl. s. a.
326	1.530	41.3	86.			
327	0.00126	−214.	−195.	0.02035 : 1 by vol.	....	i.
328	1.49 (0°)	− 11.5	26.	decomp.	decomp.	
329	1.49 (0°)	− 11.5	26.	decomp.	decomp.	
330	0.00135	−167.	−153.6	1 : 20 vol.	....	s. $FeSO_4$ sol.
331	1.527 D	− 99.	− 87.9	1.3 : 1 vol.	sl. s.	
332	1.901	10.	decomp.	i.	....	sl. s. CS_2, al.
333	2.2	178.	explodes	i.	....	s. CS_2
334	22.48	2500.	....	i.		
335	....	....	....	v. s.	s.	s. HCl; s. al.
336	....	20.	100.	s.	s.	s. alk.; s. al.
337	....	....	....	i.	i.	i. a.
338	1.653	98.	....	4.9	120.	s. al.
339	0.00143	−230.	−181.4	4.1 vol. (0°)	i.	
340	1.658 D	−270.	−119.	0.88		
341	11.4	1900.	white heat	....	....	s. HCl; s. HNO_3
342	....	decomp.	....	s.	s.	s. HCl
343	1.78	− 35.	110. expl.	s.	s.	
344	....	133.decomp.	....	s.		
345	....	....	....	s.	s.	
346	1.88	40.5	213.decomp.	....	v. s.	s. al.
347	....	61. appr.	....	v. s.	v. s.	v.s.
348	1.836	44.2	290.	i.	i.	s. CS_2
349	2.16	....	290.	i.	i.	i. CS_2
350	2.34	....	....	i.	i.	i. CS_2
351	1.65 (20°)	70.	200.decomp.	v. s.	v. s.	
352	....	148.	sublimes	decomp.	decomp.	decomp.; i. CS_2
353	1.6129	....	76.	decomp.	decomp.	s. CS_2
354	....	275.	530.	decomp.	....	decomp. by al. s. CS_2
355	2.387	sublimes	....	....	decomp.	
356	1.936	22.5	173.	decomp.		
357	1.17 D	−133.	− 85.	sl. s.	i.	
358	1.01	− 10.	30.			
359	....	....	175.decomp.	i.	i.	
360	2.431	....	....	....	v. s.	
361	....	decomp.	....	s.	v. s.	s. al.

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
362	Platinic hydroxide..	$Pt(OH)_4$	263.2	brown
363	oxide	PtO_2	227 2	black
364	sulphide	PtS_2	259 3.	black
365	Platinous chloride...	$PtCl_2$	266 1	gray
366	hydroxide	$Pt(OH)_2$	229.2	black
367	oxide	PtO	211.2	gray
368	sulphide	PtS	227.3	black
369	Platinum	Pt	195.2	
370	Potassium	K	39.15	tetragonal, white
371	Potassium acetate...	$KC_2H_3O_2$	98.12	
372	alum	$K_2SO_4+Al_2(SO_4)_3+24H_2O$	949.2	regular
373	aluminate	$K_2Al_2O_4$	196.5	
374	antimonate	$KSbO_3$	207.2	
375	arsenate	K_3AsO_4	256.5	needles
376	arsenite, sec	K_2HAsO_3	202.3	
377	bichromate	$K_2Cr_2O_7$	294.5	triclinic, red
378	bromate	$KBrO_3$	167.1	
379	bromide	KBr	119.1	regular
380	carbonate, prim...	$KHCO_3$	100.2	monoclinic
381	carbonate, sec	K_2CO_3	138.3	monoclinic
382	chlorate	$KClO_3$	122.6	monoclinic
383	chloride	KCl	74.6	regular
384	chromate	K_2CrO_4	194.4	rhombic, yellow
385	chrome alum	$K_2SO_4+Cr_2(SO_4)_3+24H_2O$	999.2	regular, red
386	cobalt nitrite	$6KNO_2.CO_2(NO_2)_6$	905.4	yellow prisms
387	cyanate	$KCNO$	81.2	blue needles
388	cyanide	KCN	65.2	regular
389	ferricyanide	$K_6Fe_2(CN)_{12}$	659.4	monoclinic, red
390	ferrocyanide	$K_4Fe(CN)_6+3H_2O$	422.9	monoclinic, yellow
391	gold cyanide (ic) ..	$Au(CN)_3.K(CN)_2+H_2O$	358.5	colorless
392	gold cyanide (ous).	$Au(CN).K(CN)$	288.4	rhombic, colorless
393	hydroxide	KHO	56.2	rhombohedric
394	hypochlorite	$KClO$	90.6	
395	hypophosphite	KH_2PO_2	104.2	hexagonal
396	iodate	KIO_3	214.	regular
397	iodide	KI	166.	regular
398	magnesium chloride	$MgCl_2+KCl+6H_2O$	278.	hexagonal, colorless
399	manganate	K_2MnO_4	197.3	rhombic, gray, black
400	nitrate	KNO_3	101.2	rhombic
401	nitrite	KNO_2	85.2	
402	oxalate	$K_2(C_2O_4).H_2O$	184.2	yellowish plates
403	oxide	K_2O	94.3	
404	perchlorate	$KClO_4$	138.6	rhombic
405	permanganate	$KMnO_4$	158.2	rhombic, black, red
406	peroxide	K_2O_4	142.3	yellow
407	persulphate	$K_2S_2O_8$	270.4	triclinic
408	phosphate (norm.)	K_3PO_4	212.5	rhombic
409	phosphate (sec.)	K_2HPO_4	174.3	
410	phosphate (prim.)	KH_2PO_4	136.2	tetragonal
411	platinum chloride (ic)	K_2PtCl_6	485.8	regular, yellow
412	platinum chloride (ous).	K_2PtCl_4	414.9	tetragonal, red
413	platinum cyanide..	$K_2Pt(CN)_4+3H_2O$	431.3	rhombic, yellow
414	pyrophosphate	$K_4P_2O_7+3H_2O$	384.7	

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 parts of Cold water.	Hot water.	Alcohol, acids, etc.
362	....	....	....	....	....	s. a.; s. KOH
363						
364	7.224	decomp.	....	i.	....	s. HCl, HNO_3
365	5.87	decomp.	....	i.	i.	s. HCl
366	....	....	....	....	....	s. HCl
367	....	decomp.				
368	....	....	....	i.	....	i. a.
369	21.1–21.7	1745.	....	i.	i.	s. aq. reg.
370	0.86	62.5	720.	decomp.	decomp.	decomp. by al.
371	....	....	....	188.	492.	al. 33
372	1.73	92.	red heat	9.5	357.	
373	....	....	....	s.		
374	....	....	....	i.	decomp.	
375	....	....	....	18.87	v. s.	s. al. 4
376	....	....	....	v. s.	v. s.	
377	2.69	decomp. at	red heat	12.4 (20°)	94.	i. al.
378	3.271	....	decomp.	6.667	49.75	sl. s. al.
379	2.681	750.	subl. white heat	64.4	100.	s. al.
380	2.25	decomp.	....	25. (5°)	59. (59°)	al. 0.0833 (hot)
381	2.3	1045.	....	109.	156.	i. al.
382	2.326	334.	decomp.	6.25	50.	al. 0.833
383	1.995	790.	subl. white heat	32.	56.6	al. 0.5
384	2.7	red heat	....	50.	60.	i. al
385	1.83	400.	....	20.	50.	i. al.
386	....	....	....	sl. s.	sl. s.	i. al.
387	2.048	....	....	s.	....	s. al.
388	1.54	red heat	....	v. s.	decomp.	sl. s. al.
389	1.861	....	....	40.	80.	i. al.
390	2.05	....	....	28.	100.	i. al.
391	....	....	....	s.	s.	i. al.
392	....	....	....	14.3	200.	
393	2.044	red heat	subl. white heat	200.	v. s.	s. al.
394	....	decomp.	....	v. s.	v. s.	
395	....	decomp.				
396	3.98	560.	....	8. (20°)	32. (100°)	
397	3.06	705.	....	128.	209.	al. 14.28
398	1.618	red heat	....	64.5 (18°)	decomp.	
399	....	....	....	s.	decomp.	s. alk.
400	2.078	339.	decomp.	25.	247.	i. al.
401	....	....	....	....	v. s.	s. al.
402	2.08	decomp.	....	33.		
403	2.56	....	....	v. s.	v. s.	v. s. al.
404	2.54	610.	....	1.667	18.18	i. al.
405	2.71	decomp.	....	6.45	v. s.	decomp.
406	....	red heat	decomp.	white heat decomp.	....	decomp. by al.
407	....	decomp.	....	1.76	decomp.	
408	....	....	....	s.	....	i. al.
409	....	decomp.	....	v. s.	v. s.	v. s. al.
410	2.3	decomp.	....	v. s.	....	i. al.
411	3.344	decomp.	....	0.92	5.263	1:42600 al.
412	3.3 (20°)	....	....	s.	s.	i. al.
413	2.52	100.	decomp. at	red heat	s.	s. al.; s. H_2SO_4
414	2.33	....	....	s.	v. s.	

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
415	Potassium pyrosulphate	$K_2S_2O_7$	254.4	
416	silver cyanide	Ag(CN).K(CN)	199.2	white
417	silicate	K_2SiO_3	154.7	
418	silicofluoride	K_2SiF_6	220.7	regular
419	sulphate, norm.	K_2SO_4	174.4	rhombic
420	sulphate, prim	$KHSO_4$	136.2	rhombic
421	sulphide	K_2S	110.4	red
422	sulphite, norm.	$K_2SO_3+2H_2O$	194.4	rhombic
423	sulphite, prim.	$KHSO_3$	120.2	
424	sulphocyanate	KCNS	97.3	
425	tri-iodide	KI_3	419.7	prisms
426	Rubidium	Rb	85.4	white
427	Rubidium carbonate	Rb_2CO_3	230.8	colorless
428	chloride	RbCl	120.9	regular, colorless
429	hydroxide	Rb(OH)	102.4	white
430	nitrate	$RbNO_3$	147.4	needles
431	sulphate	Rb_2SO_4	266.9	colorless, rhombic
432	Silicon	Si	28.4	
433	Silicon carbide	SiC	40.4	rhombic
434	chloride	$SiCl_4$	170.2	
435	fluoride	SiF_4	104.4	
436	hydride	SiH_4	32.4	
437	trichloride	Si_2Cl_6	269.5	white
438	Silver	Ag	107.9	regular, white
439	Silver arsenate	Ag_3AsO_4	462.8	red
440	arsenite	Ag_3AsO_3	446.8	yellow
441	bromide	AgBr	187.9	regular, yellow
442	chloride	AgCl	143.4	regular, white
443	cyanide	Ag(CN)	134.	white
444	iodide	AgI	234.8	hexagonal, yellow
445	nitrate	$AgNO_3$	170.	rhombic
446	nitrite	$AgNO_2$	154.	white crystals
447	oxide	Ag_2O	231.9	black
448	peroxide	Ag_2O_2	247.9	regular, black
449	phosphate, norm.	Ag_3PO_4	418.8	yellow
450	sulphate	Ag_2SO_4	311.9	rhombic
451	sulphide	Ag_2S	247.9	regular, gray or black
452	thiosulphate	$Ag_2S_2O_3$	327.	white
453	Sodium	Na	23.05	tetragonal, white
454	Sodium acetate	$Na(C_2H_3O_2).3H_2O$	136.7	monoclinic prisms
455	alum	$Al_2(SO_4)_3.Na_2SO_4+24H_2O$	917.	regular
456	aluminate	$Na_2Al_2O_4$	164.3	
457	aluminum chloride	$Al_2Cl_6+2NaCl$	383.9	colorless
458	ammonium phosphate	$NH_4.NaHPO_4+4H_2O$	209.2	monoclinic, colorless
459	antimonate, pyro-	$Na_2H_2Sb_2O_7+H_2O$	418.1	
460	arsenate	$Na_2HAsO_4+12H_2O$	402.4	
461	arsenite	Na_2HAsO_3	170.1	
462	bichromate	$Na_2Cr_2O_7+2H_2O$	289.3	triclinic, red
463	borate, Borax	$Na_2B_4O_7+10H_2O$	382.3	monoclinic
464	bromide	$NaBr(+2H_2O)$	103.	monoclinic
465	carbonate	$Na_2CO_3+10H_2O$	286.3	monoclinic

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 parts of		
				Cold water.	Hot water.	Alcohol, acids, etc.
415	2.27	decomp.	....	s.		
416	....	....	....	12.5	100.	al. 4
417	....	....	....	....	s.	
418	2.66	decomp. at	red heat	0.1265	2.	i. al.
419	2.648	1050.	sublimes	8.5 (0°)	26.	i. al.
420	2.163	197.	decomp.	v. s.	v. s.	
421	2.13	....	....	v. s.	v. s.	s. al.
422	....	....	....	100.	v. s.	i. al.
423	....	190 decomp.	....	s.	s.	i. al.
424	1.886	161.	....	v. s.	v. s	s. al.
425	3.498	45.	....	decomp.	....	s. KI sol.
426	1.52	38.5	red heat	decomp.		
427	....	837.	....	....	v. s.	
428	2.2	red heat	....	82.9		
429	....	below red heat	....	1.18 (25°)	11.76	s. al.
430	....	....	....	20.1 (0°)	43.5 (10°)	v. s. HNO_3
431	....	....	....	42.4 (10°)		
432	2.49	white heat	....	i.	i.	s. HF; HNO_3
433	3.22 (15°)	....	....	i.	i.	i. a
434	1.523	− 89.	56.5	decomp.		
435	3.57 D	− 97.	− 77.	decomp.		
436	....	−200.	− 11.50 (50 atm.)	i.		
437	1.58	240.	146.–148.	decomp.	decomp.	
438	10.47	962.	white heat	i.	i.	s. HNO_3
439	....	....	....	i.		
440	....	....	....	i.	i.	s. HNO_3; s. NH_3
441	6.39	426.	700.	i.	i.	
442	5.501	460.	....	i.	i.	s. NH_3, KCN, conc. HCl
443	3.99	....	....	i.	i.	s. NH_3, KCN
444	5.687	556.	....	i.	i.	sl. s. NH_3, s. conc. KI
445	4.35	208.6	decomp. red heat	122. (0°)	1111.	
446	....	....	decomp. red heat	sl. s.	s.	s. NH_3
447	7.2	250.decomp.	....	0.333	....	s. HNO_3
448	....	....	....	i.	....	s. HNO_3, NH_3
449	7.32	red heat	....	i.	....	s. alk. and a.
450	5.41	....	....	0.5	1.45	v. s. ammonia
451	7.24	....	....	i.	....	i. NH_3
452	....	decomp.	....	sl. s.	....	s. NH_3
453	0.973	95.6	742.	decomp.	decomp.	decomp.
454	1.4	58.	....	26.	200.	s. al.
455	1.6	50.	....	110.	v. s.	
456	....	....	....	s.	s.	
457	....	185.	red heat			
458	1.55	decomp.	....	16.	100.	i. al.
459	....	....	....	sl. s.	sl. s.	sl. s. al.
460	1.67	....	....	28.	v. s.	al. 1.8
461	1.87	....	....	v. s.	v. s.	
462	2.52 (16°)	320.	400.	107. (0°)	163. (100°)	
463	1.69	red heat	....	6.	200.	i. al.
464	3.1	712.	....	75.	112.	sl. s. al.
465	1.45	34.	106.	92.8	539.6	i. al.

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
466	Sodium carbonate	Na_2CO_3	106.1	
467	carbonate, prim	$NaHCO_3$	84.1	monoclinic
468	chlorate	$NaClO_3$	106.5	regular
469	chloride	$NaCl$	58.5	regular
470	chromate	$Na_2CrO_4+10H_2O$	342.4	monoclinic, yellow
471	hydroxide	$NaOH$	40.1	
472	hypochlorite	$NaOCl$	74.5	
473	hypophosphite	$NaH_2PO_2+H_2O$	106.1	
474	nitrate	$NaNO_3$	85.1	rhombohedric
475	nitrite	$NaNO_2$	69.1	
476	oxide	Na_2O	62.1	
477	perchlorate	$NaClO_4$	122.5	rhombohedric, colorless
478	permanganate	$NaMnO_4$	142.1	red
479	phosphate, meta-	$NaPO_3$	102.1	white
480	phosphate, norm	$Na_3PO_4+12H_2O$	380.4	hexagonal
481	phosphate, prim	$NaH_2PO_4+H_2O$	138.1	rhombic
482	phosphate, pyro	$Na_4P_2O_7+10H_2O$	446.4	monoclinic
483	phosphate, sec	$Na_2HPO_4+12H_2O$	358.4	monoclinic
484	phosphite	$Na_2HPO_3+5H_2O$	216.2	rhombohedric
485	platinum chloride	$Na_2PtCl_6+6H_2O$	561.7	triclinic, red
486	silicate	Na_2SiO_3	122.5	monoclinic
487	sulphate	$Na_2SO_4+10H_2O$	322.4	monoclinic
488	sulphate, prim	$NaHSO_4+H_2O$	138.1	monoclinic
489	sulphide	$Na_2S(+9H_2O)$	240.3	crystals
490	sulphite	$Na_2SO_3+7H_2O$	252.3	monoclinic
491	peroxide	Na_2O_2	78.	white, yellow
492	thiosulphate	$Na_2S_2O_3+5H_2O$	248.3	monoclinic
493	Stannic acid	H_2SnO_3	169.	white
494	chloride	$SnCl_4$	260.5	
495	oxide	SnO_2	151.	tetragonal, amorphous, white.
496	Stannic sulphide	SnS_2	183.1	hexagonal, yellow
497	Stannous chloride	$SnCl_2+2H_2O$	226.	triclinic
498	oxide	SnO	135.	regular
499	sulphide	SnS	151.1	gray
500	Strontium	Sr	87.6	yellow
501	Strontium carbonate	$SrCO_3$	147.9	rhombic
502	chloride	$SrCl_2+6H_2O$	266.5	hexagonal
503	hydroxide	$Sr(OH)_2+8H_2O$	265.7	tetragonal
504	nitrate	$Sr(NO_3)_2$	211.6	regular
505	oxide	SrO	103.5	rhombic
506	peroxide	SrO_2+8H_2O	263.7	crystals
507	sulphate	$SrSO_4$	183.6	rhombic
508	Sulphur, amorphous	S_8	256.6	
509	Sulphur, octahedral	S_8	256.6	rhombic, yellow
510	Sulphur, prismatic	S_8	256.6	monoclinic
511	Sulphur chloride	SCl_2	103.	brown
512	dioxide	SO_2	64.1	
513	Sulphuric acid, conc.	H_2SO_4(98.5%)	98.1	
514	Sulphuric acid, anhydrous.	H_2SO_4	98.1	
515	Sulphuric acid, pyro	$H_2S_2O_7$	178.1	prisms
516	Sulphur subchloride	S_2Cl_2	135.	yellow
517	trioxide	SO_3	80.1	white needles
518	Tantalum	Ta	181.5	gray

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 parts of Cold water.	Hot water.	Alcohol, acids, etc.
466	2.5	849.	....	21.4	45.	i. al.
467	2.2	decomp.	....	8.	decomp.	i. al.
468	2.29	302.	decomp.	100.	333. (120°)	s. al.
469	2.13	820.	white heat	35.	39.5	i. al.
470	2.71	23.	....	s.	s.	
471	2.13	below red heat	....	60.	250.	s. al.
472	....	....	....	s.		
473	....	....	....	....	s.	
474	2.26	330.	....	80.	200.	s. al.
475	....	213.	....	83.	v. s.	i. al.
476	2.805	red heat	sublimes	decomp.	....	decomp. by al.
477	....	decomp.	....	....	v.s.	
478	....	decomp.	....	....	v. s.	
479	2.476	617.	....	i.		
480	1.62	....	....	20.	s.	
481	2.04	200. decomp.	....	s.	....	i. al.
482	1.8	....	76.7	5.4 (0°)	93.	i. al.
483	1.525	38.	....	....	96.	i. al.
484	....	53.	....	s.	s.	
485	2.499	....	....	v. s.	v. s.	s. al.
486	....	....	....	s.	s.	i. al.
487	1.48	....	....	12.16	412. (34°)	i. al.
488	1.8	300.	....	v. s.	v. s.	i. al.
489	....	....	....	s.	s.	s. al.
490	1.55	decomp.	....	25.	100.	i. al.
491	....	....	....	s. decomp.	decomp.	
492	1.73	48.	220. decomp.	102. (16°)	171. (45°)	i. al.
493	....	....	....	....	....	i. HNO_3
494	2.27	−29.	120.	s., decomp. with much H_2O		s. CS_2
495	6.8	....	....	i.	....	s. alk.; i. a.
496	4.5	red heat decomp.	....	i.	....	s. al.
497	2.71	40.	606.	665.	....	s. al.
498	6.11	decomp.	red heat	i.	....	s. NH_4Cl
499	4.97	red heat	....	i.	....	s. HCl
500	2.542	800.	1000.	decomp.	decomp.	
501	3.62	decomp. at	red heat	0.0056		
502	1.603	854.	100.	44. (0°)	117. (118°)	al. 4.6
503	1.396	100.	....	2. (10°)	41. (100°)	
504	2.962	570.	....	40. (0°)	103. (108°)	sl. s. al.
505	4.75	....	....	0.35(0°)	21.	
506	....	decomp.	red heat	sl. s.		
507	3.71–3.95	....	....	0.0145 (0°)	0.01 (100°)	sl. a.
508	2.046	120.	....	i.	i.	i. CS_2
509	2.07	114.–115.	448.4	i.	i.	sl. s. al.; s. CS_2
510	1.957	120.	448.4	i.	i.	s. CS_2
511	1.62	....	70. decomp.	decomp.	decomp.	
512	2.23 D	−79.	−8.	688. vol.	170. vol.	al. 328. vol.
513	1.854	....	....	s. a. p.	s. a. p.	
514	1.842	10.5	40.	s. a. p.	s. a. p.	
515	1.89	35.	....	decomp.	decomp.	decomp.
516	1.706	....	138.	sl. decomp.	decomp.	s. CS_2
517	1.954	14.8	46.	decomp.	decomp.	
518	16.5	2300.				

PHYSICAL CONSTANTS OF

	Name.	Formula.	Mol. wt.	Crystalline form and color.
519	Tantalum chloride	$TaCl_5$	358.8	yellow
520	oxide	Ta_2O_5	442.	white
521	Tellurium	Te	127.5	white, gray
522	Telluric acid	$H_2TeO_4+2H_2O$	229.1	hexagonal
523	oxide	TeO_3	175.	yellow crystals
524	Tellurous acid	H_2TeO_3	177.	white
525	oxide	TeO_2	159.	regular, yellow
526	Thallium	Tl	204.1	
527	chloride (ic)	$TlCl_3+H_2O$	328.5	
528	chloride (ous)	TlCl	239.6	regular, white
529	hydroxide (ous)	TlOH	221.1	
530	oxide (ic)	Tl_2O_3	456.2	black, hexagonal
531	oxide (ous)	Tl_2O	424.1	black
532	nitrate (ous)	$TlNO_3$	266.1	rhombic
533	sulphate (ous)	Tl_2SO_4	504.2	rhombic
534	sulphide (ous)	Tl_2S	440.2	brown
535	Thorium nitrate	$Th(NO_3)_4$	480.7	
536	oxide	ThO_2	264.5	regular, amorphous, white
537	Tin	Sn	118.7	white
538	Titanium	Ti	48.1	gray
539	tetrachloride	$TiCl_4$	189.9	
540	oxide	TiO_2	80.1	tetragonal, rhombic.
541	Tungsten	W	184.	tetragonal, gray, white
542	Tungsten dioxide	WO_2	216.	brown
543	hexachloride	WCl_6	396.7	black
544	trioxide	WO_3	232.	rhombic, yellow
545	Uranium	U	238.2	
546	Uranyl chloride	UO_2Cl_2	341.4	red, brown
547	nitrate	$UO_2(NO_3)_2+6H_2O$	502.7	yellow crystals
548	Vanadium	V	51.2	crystals
549	Vanadium chloride	VCl_2	122.1	hexagonal, yellow
550	dioxide	V_2O_2	134.4	gray powder
551	pentoxide	V_2O_5	182.4	rhombic, red
552	trioxide	V_2O_3	150.4	black
553	Yttrium oxide	Y_2O_3	226.	white crystals
554	nitrate	$Y(NO_3)_3+6H_2O$	383.	colorless
555	Zinc	Zn	65.4	hexagonal, white
556	Zinc carbonate	$ZnCO_3+H_2O$	143.4	rhombohedric
557	chloride	$ZnCl_2$	136.3	
558	hydroxide	$Zn(OH)_2$	99.4	rhombic
559	nitrate	$Zn(NO_3)_2+6H_2O$	297.6	tetragonal
560	orthophosphate	$Zn_3(PO_4)_2$	386.2	prisms
561	oxide	ZnO	81.4	white
562	sulphate	$ZnSO_4+7H_2O$	287.6	rhombic
563	sulphide	ZnS	97.5	regular
564	Zirconium oxide	ZrO_2	122.7	tetragonal

INORGANIC COMPOUNDS (Continued)

	Sp. gr. water 1 D. air 1	Melting-point, Deg. C.	Boiling-point, Deg. C.	Solubility in 100 parts of		
				Cold water.	Hot water.	Alcohol, acids, etc.
519	12 8 D	221.	241.6	decomp.	....	s. al.
520	7.5	....	....	i.	....	s. $KHSO_4$
521	6.26	450.	1390.	i.	i.	s. H_2SO_4
522	....	decomp. red heat	160.	s.		
523	....	decomp.	red heat	i.		
524	....	40. decomp.	....	sl. s.	decomp.	
525	5.9	red heat	700. appr.	i.		
526	11.862	296.	white heat	i.	....	s. HNO_3
527	....	100. decomp.	....	v. s.	decomp.	
528	7.02	....	....	0.265 (16°)	1.427	i. HCl, al.
529	....	100. decomp.	....	s.		
530	5.56 (0°)	....	....	i.	i.	s. HCl
531	....	300.	....	s.		
532	5.55	205.	....	10.67 (18°)	508.2 (108°)	i. al.
533	6.603	red heat	....	4.8 (18°)	19.3 (100°)	
534	8.	....	decomp.	i.	i.	i. alk.; s. a.
535	....	....	....	....	....	s. al.
536	9.8	....	....	....	....	s. conc. H_2SO_4
537	7.29	231.	white heat	i.	....	s. a.
538	3.5	....	....	....	....	s. HCl
539	1.76	−25.	136.	s.	decomp.	
540	3.9–4.3	....	....	i.		
541	19.13	above 1900	....	i.	....	s. HNO_3; i. HCl, H_2SO_4
542	12.1	....	....	i.	....	sl. s. a.; s. KOH
543	....	275.	346.	....	....	s. CS_2
544	7.16	red heat	....	i.	....	s. alk.
545	18.68	white heat	....	i.	i.	s. a.
546	....	....	....	s.	s.	s. al.
547	2.8	59.5	....	200.	v. s.	v. s. al.
548	5.5	1680.	....	....	....	s. HNO_3, conc. H_2SO_4
549	3.23	....	....	s.	s.	s. al.
550	3.64	....	....	i.	i.	s. a.
551	3.35	....	....	1:1000	....	s. a.; s. alk.
552	4.72	....	....	s.	s.	s. HNO_3; i. alk.
553	5.046	....	....	i.	....	s. a.
554	....	170.	....	....	....	s. al. and ether
555	6.86–7.21	419.	930.	i.	decomp.	s. a.
556	4.3–4.5	....	....	i.	i.	i. al.
557	2.753	100.	730.	300.	v. s.	s. al.
558	2.877	decomp.	....	i.	i.	s. al.; s. a.
559	....	105.	....	....	v. s.	s. al.
560	3.99	red heat				
561	5.61	....	....	1:100000	....	s. a.
562	1.95	100.	red heat	135.	655.	i.
563	3.5	....	....	i.	i.	
564	5.45	....	....	i.	....	s. conc. H_2SO_4

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Acetal	diethylacetal	$CH_3 \cdot CH(OC_2H_5)_2$	118.1
2	Acet-aldehyde	ethylaldehyde	$CH_3 \cdot CHO$	44.
3	amide	ethanamide	$CH_3 \cdot CO(NH_2)$	59.1
4	anilid	phenylacetamide, antifebrin	$C_6H_5NHC_2H_3O$	135.1
5	Acetic acid		CH_3CO_2H	60.
6	anhydride	acetyl oxide, acetic oxide	$(CH_3CO)_2O$	102.1
7	Aceto-acetic acid		$CH_3 \cdot CO \cdot CH_2 \cdot CO_2 \cdot H$	102.1
8	ether	ethyl acetoacetate	$CH_3 \cdot CO \cdot CH_2 \cdot CO_2 \cdot C_2H_5$	130.1
9	Acetone	dimethylketone	$CH_3 \cdot CO \cdot CH_3$	58.1
10	Aceto-phenone	hypnone, phenylmethylketone	$CH_3 \cdot CO \cdot C_6H_5$	120.1
11	Acetyl bromide		$CH_3 \cdot CO\ Br$	123.
12	chloride		$CH_3 \cdot CO\ Cl$	78.5
13	Acetylene		$CH \vdots CH$	26.
14	Aconitic acid	equisetic acid	$C_3H_3(CO_2H)_3$	174.1
15	Acridine		$C_6H_4 < {CH \atop N} > C_6H_4$	179.1
16	Acrolein		$CH_2 : CH \cdot CHO$	56.
17	Acrylic acid		$CH_2 : CH \cdot CO_2H$	72.
18	Aldehyde-ammonia	ammoniated ethylic aldehyde	$CH_3 \cdot CH(OH)NH_2$	61.1
19	Aldol		$CH_3 \cdot CH(OH) \cdot CH_2 \cdot COH$	88.1
20	Alizarine	orthodihydroxyanthraquinone, dioxyanthraquinone	$C_6H_4(CO)_2C_6H_2(OH)_2$	240.1
21	Allyl alcohol		$C_3H_5 \cdot OH$	58.1
22	amine		$C_3H_5 \cdot NH_2$	57.1
23	chloride		C_3H_5Cl	76.5
24	cyanide		$C_3H_5 \cdot CN$	67.1
25	ether		$(CH_2 : CH \cdot CH_2)_2O$	98.1
26	isoamyl ether		$C_3H_5 \cdot O \cdot C_5H_{11}$	128.1
27	isocyanide		$C_3H_5 \cdot NC$	67.1
28	mustard oil		$CH_2 : CH \cdot CH_2NCS$	99.1
29	Allylene	propine, methylacetylene	$CH_3 \cdot C \vdots CH$	40.
30	Aluminum methyl		$Al(CH_3)_3$	72.2
31	Amino-acetone		$NH_2CH_2 \cdot CO \cdot CH_3$	73.1
32	azo-benzene (p.)	amidoazobenzene, anilin yellow	$C_6H_4(NH_2) \cdot N_2C_6H_5$	197.2
33	benzene-sulphonic acid (o.)		$C_6H_4 \cdot NH_2 \cdot SO_3H$	173.2
34	benzene-sulphonic acid (m.)		$C_6H_4 \cdot NH_2 \cdot SO_3H$	173.2
35	benzoic acid (o.)	anthranilic acid	$C_6H_4(NH_2) \cdot COOH$	137.1
36	" " (m.)	benzaminic acid	$C_6H_4(NH_2) \cdot COOH$	137.1

Abbreviations: acet., acetic acid; alk., alkali; anh., anhydrous; c., cold; colorl., colorless; dec. or decomp., decomposes; deliq., deliquescent; expl., explodes; hex., hexagonal; h., hot; i., insoluble; leaf., leaflets; lg., long.

ORGANIC COMPOUNDS

No.	Crystalline form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in		
					Water	Alcohol	Ether
1	fluid	0.821(21°)	....	105.	c.1:18	s.	s.
2	fluid	0.801(0°)	....	20.8	s. a. p.	s.	s.
3	hex.	1.14	82.	222.	v. s.	v. s.	v. s.
4	leaflets...	1.21(4°)	112.	305.	i.	s.	....
5	....	1.057(15°)	17.	119.	s. a. p.	s. a. p.	s. a. p.
6	fluid	1.073	....	138.	....	....	....
7	fluid	....	....	decomp.	v. s.	....	....
8	....	1.026(20°).	....	181.	sl. s.	....	....
9	fluid	0.792	....	56.3	s.	s.	s.
10	....	1.032	20.	200.	sl. s.	....	....
11	....	....	....	81.	....	....	....
12	fluid	1.1305	....	50.9	decomp.	....	....
13	gas	0.92(air)	-82.	....	1:1	....	....
14	....	....	191.	....	18:100	1:2	s.
15	leaf. or need.	....	107.	360. +sub.	sl. s.	v. s.	v. s.
16	....	0.84	....	52.4	40:100	s.	s.
17	....	1.062	8.	140.	s. a. p.-	....	....
18	rhombic..	....	97.2	decomp.	s.	....	sl. s.
19	syrup	1.109(16°)	....	90.-105.	s.	s.	s.
20	red need.	....	289-290.	subl.	i.	s.	s.
21	fluid	0.8578	....	97.	s. a. p.	s.	....
22	fluid	....	....	58.	....	s.	....
23	fluid	0.934	....	46	i.	s.	....
24	fluid	0.839(0°)	....	118.119	....	s.	....
25	fluid	....	....	94.3	i.	s.	....
26	....	....	....	120	....	....	....
27	fluid	0.794	....	96.106	sl. s.	s.	....
28	fluid	1.017(10°)	....	150.7	sl. s.	s.	s.
29	gas	....	....	....	....	....	....
30	fluid	....	....	130.	....	....	....
31	need.	....	188-189. decomp.	....	v. s.	s.	....
32	yellow leaves	....	127.	....	....	s.	s. benzol
33	....	....	....	....	1.66:100	s.	....
34	....	....	....	....	1.68:100	s.	....
35	....	....	144.	....	s. h.	s.	s.
36	....	1.515(4°)	173-174.	....	s. h.	s.	s.

Abbreviations (cont.): m., meta-; need., needles; n., normal; o., ortho-; p., para-; rhomb., rhombic; r., red; sl., slightly; s., soluble; s. a. p., soluble in all proportions; subl., sublimes; tabl., tablets; tetr., tetragonal; tricl., triclinic; v., very; vol., volume; yw., yellow.

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Amino-benzoic acid (p.)	amidodracylic acid	$C_6H_4(NH_2)\cdot COOH$	137.1
2	cinnamic acid (o.)	....	$NH_2\cdot C_6H_4\cdot C_2H_2CO_2H$	163.1
3	" " (m.)	....	$NH_2C_6H_4C_2H_2CO_2H$	163.1
4	" " (p.)	....	$NH_2C_6H_4C_2H_2CO_2H$	163.1
5	phenol (o.)	oxanilin hydrochloride	$C_6H_4\cdot OH\cdot NH_2$	109.1
6	" (m.)	....	$C_6H_4\cdot OH\cdot NH_2$	109.1
7	" (p.)	....	$C_6H_4OH\cdot NH_2$	109.1
8	Amygdaline	....	$C_{20}H_{27}NO_{11}+3H_2O$	511.3
9	Amyl acetate	amylacetic ester	$CH_3CO_2\cdot C_5H_4$	130.1
10	alcohol, normal	....	$C_4H_9\cdot CH_2\cdot OH$	88.1
11	" active	....	$CH_3(C_2H_5)CH\cdot CH_2\cdot OH$	88.1
12	" secondary	....	$C_3H_7CH(OH)\cdot CH_3$	88.1
13	" tertiary	....	$(CH_3)_2\cdot C(OH)\cdot C_2H_5$	88.1
14	chloride, normal	....	$C_5H_{11}Cl$	106.5
15	cyanide	capronitrile	$C_5H_{11}CN$	97.1
16	ether	amyl oxide	$(C_5H_{11})_2O$	158.2
17	Amylene	trimethylethylene	$(CH_3)_2C:CH\cdot CH_3$	70.1
18	Anilin	phenylamine, amidobenzene	$C_6H_5\cdot NH_2$	93.1
19	Anisol	methylphenylether	$C_6H_5\cdot O\cdot CH_3$	108.1
20	Anthracene	paranaphthalene	$C_6H_4\cdot C_2H_2:C_6H_4$	178.1
21	Anthranil	....	$C_6H_4:NH\cdot CO$	119.1
22	Anthraquinoline	....	$C_{17}H_{11}N$	229.1
23	Anthraquinone	....	$C_6H_4(CO)_2C_6H_4$	208.1
24	Arabinose (l.)	pectinose, pectin sugar	$C_4H_5(OH)_4CHO$	150.1
25	Asparagine (l.)	aminosuccinamic acid	$C_2H_3(NH_2)(CO_2H)CO\cdot NH_2$	132.1
26	Azobenzene	azobenzol	$(C_6H_5)_2N_2$	182.2
27	Azobenzoic acid (o.)	....	$C_{14}H_{10}N_2O_4$	270.2
28	" " (m.)	....	$C_{14}H_{10}N_2O_4+\frac{1}{2}H_2O$	279.2
29	" " (p.)	....	$C_{14}H_{10}N_2O_4+\frac{1}{2}H_2O$	279.2
30	Azotoluene (o.)	....	$(C_7H_7)_2N_2$	210.2
31	" (m.)	....	$(C_7H_7)_2N_2$	210.2
32	" (p.)	....	$(C_7H_7)_2N_2$	210.2
33	Azoxybenzene	....	$(C_6H_5)_2N_2O$	198.2
34	Azoxybenzoic acid (o.)	....	$C_{14}H_{10}N_2O_5$	286.2
35	Azoxybenzoic acid (m.)	....	$C_{14}H_{10}N_2O_5$	286.2
36	Azoxybenzoic acid (p.)	....	$C_{14}H_{10}N_2O_5$	286.2
37	Benzal chloride	benzyl dichloride	C_6H_5CHCl	161.
38	Benzalcohol	benzyl alcohol	$C_6H_5CH_2OH$	108.1
39	Benzaldehyde	benzoic aldehyde, artificial oil of almond	C_6H_5COH	106.1
40	Benzaldoxime (α) (anti)	....	$C_6H_5\cdot CH:N\cdot OH$	121.1
41	Benzaldoxime (β)	....	$C_6H_5\cdot CH:N\cdot OH$	121.1

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	....	....	186–187.	....	v. s.	s.	s.
2	yellow need.	....	158–159.	....	sl. s.	s.	s.
3	long yellow need.	....	180–181.	....	sl. s.	s.	s.
4	fine yellow need.	....	175–176.	....	sl. s.	v. s.	v. s.
5	....	....	170.	subl.	1:59(0°)	1:23	s.
6	....	....	120.	....	s. h.	s.	s.
7	....	....	184. decomp.	subl.	1:90(0°)	1:22(0°)	....
8	....	....	215.	....	8:100(10°)	s. h.	i.
9	fluid	0.857	....	148.	i.	s.	s.
10	fluid	0.8121(20°)	....	137.	i.	....	....
11	fluid	0.833	....	128.7	....	....	....
12	fluid	0.8239	....	118.5	16:100	....	....
13	fluid	0.814(15°)	−12.	101.8	sl. s.	s.	....
14	fluid	0.9013(0°)	....	106.6	....	s.	....
15	fluid	0.866(20°)	....	146.	sl. s.	s.	s.
16	fluid	0.7994(0°)	....	176.	i.	....	....
17	fluid	0.6807(1°)	....	35.	....	....	....
18	fluid	1.022(20°)	−8.	182.	3:100	v. s.	v. s.
19	fluid	0.991	....	155.	i.	s.	s.
20	....	1.147	217.	360.	i.	sl. s.	sl. s.
21	oil	....	18.	210-215.	sl. s.	v. s.	....
22	leaflets	....	170.	446.	i.	s.	s.
23	....	1.425	285.	380.	i.	sl. s.	sl. s.
24	prisms	....	160.	....	s.	i.	....
25	....	1.519(14°)	decomp.	decomp.	h. 23:100	sl. s.	sl. s.
26	orange, mono-clinic	1.20	68.	293.	i.	s.	s.
27	yellow need.	....	250. decomp.	....	sl. s.	s.	....
28	white, amorphous	....	....	decomp.	sl. s.	sl. s.	sl. s.
29	red, amorphous	....	....	decomp.	sl. s.	sl. s.	sl. s.
30	red, prismatic	....	55.	....	i.	s.	s.
31	orange, rhombic	....	54.	....	i.	s.	s.
32	orange need.	....	144.	....	i.	sl. s.	s.
33	yellow rhombic need.	....	36.	decomp.	i.	i.	i.
34	rhombic prisms	....	....	....	sl. s.	s. h.	....
35	blue needles.	....	....	....	i.	sl. s.	sl. s.
36	yellow prisms	....	....	decomp. 240.	....	i.	....
37	....	1.295(16°)	....	213.	....	....	....
38	fluid	1.041(22°)	....	206.	i.	s.	s.
39	....	1.0455(20°)	....	179.1	1:300	s.	....
40	....	1.11(20°)	35.	200.	sl. s.	v. s.	v. s.
41	needles	....	128-130.	....	....	....	sl. s.

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Benzamide		$C_6H_5 \cdot CO \cdot NH_2$	121.1
2	Benzanilid	benzoylanilid	$C_6H_5CONHC_6H_5$	197.1
3	Benzene	benzol, phenyl hydride	C_6H_6	78.1
4	hexabromide		$C_6H_6Br_6$	457.8
5	hexachloride	benzene alphahexachloride	$C_6H_6Cl_6$	290.8
6	sulphinic acid		$C_6H_5SO_2H$	142.1
7	sulphone amide		$C_6H_5 \cdot SO_2 \cdot NH_2$	157.2
8	sulphone chloride		$C_6H_5 \cdot SO_2Cl$	176.6
9	sulphonic acid		$C_6H_5 \cdot SO_3H + H_2O$	176.1
10	Benzidine (p.)	paradiaminodiphenyl	$NH_2 \cdot C_6H_4 \cdot C_6H_4 \cdot NH_2$	184.1
11	Benzil	dibenzoyl	$C_6H_5CO \cdot CO \cdot C_6H_5$	210.1
12	Benzoic acid	phenylformic acid	$C_6H_5CO_2H$	122.1
13	anhydride	benzoyl oxide	$(C_7H_5O)_2O$	226.1
14	Benzophenone	diphenylketone	$(C_6H_5)_2CO$	182.1
15	Benzoyl-acetic acid		$C_6H_5 \cdot CO \cdot CH_2 \cdot CO_2H$	164.1
16	benzoic acid (o.)		$C_6H_5 \cdot CO \cdot C_6H_4 \cdot CO_2H + H_2O$	244.1
17	" " (m.)		$C_6H_5 \cdot CO \cdot C_6H_4 \cdot CO_2H$	226.1
18	" " (p.)		$C_6H_5 \cdot CO \cdot C_6H_4 \cdot CO_2H$	226.1
19	bromide		$C_6H_5 \cdot COBr$	185.
20	chloride		$C_6H_5 \cdot CO \cdot Cl$	140.5
21	cyanide		$C_6H_5 \cdot CO \cdot CN$	131.1
22	Benzyl acetate		$C_7H_7C_2H_3O_2$	150.1
23	carbinol		$C_6H_5 \cdot CH_2 \cdot CH_2OH$	122.1
24	chloride	omegachlorotoluene	$C_6H_5 \cdot CH_2 \cdot Cl$	126.5
25	cyanide	phenylacetate-acid nitrile	$C_6H_5CH_2CN$	117.1
26	Biuret	allophanamide	$NH\ (CO \cdot NH_2)_2$	103.2
27	Borneol (i.)	Borneo champhor, camphol	$C_{10}H_{18}O$	154.2
28	" (d.)		$C_{10}H_{18}O$	154.2
29	Bromacetic acid	monobromacetic acid	$CH_2Br \cdot CO_2H$	139.
30	Bromacetylene		C_2HBr	105.
31	Bromal	tribromacetaldehyde	$CBr_3 \cdot COH$	280.9
32	Bromanilin (o.)		$C_6H_4 \cdot NH_2 \cdot Br$	172.1
33	" (m.)		$C_6H_4 \cdot NH_2 \cdot Br$	172.1
34	" (p.)		$C_6H_4 \cdot NH_2 \cdot Br$	172.1
35	Brombenzamide (o.)		$C_6H_4 \cdot CONH_2Br$	200.1
36	" (m.)		$C_6H_4 \cdot CONH_2Br$	200.1
37	" (p.)		$C_6H_4 \cdot CONH_2Br$	200.1
38	Brombenzene		C_6H_5Br	157.

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O = 1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	monoclinic	1.341	128.	290.	sl. s.	s.	s.
2	....	1.31(4°)	158-163.	dist.	i.	s.	sl. s.
3	rhombic	0.87907 (20°)	6.	80.36	i.	s.	s.
4	monoclinic	....	212.	....	....	s.	s.
5	....	....	157.	288. decomp.	....	....	....
6	large prisms	....	83.	100. decomp.	sl. s.	s.	s.
7	need. or leaflets	....	149-156.	....	i.	v. s. h.	s.
8	....	1.378(23°)	14.	247. decomp.	i.	s.	s.
9	....	....	66.	....	s.	s.	s.
10	white leaflets	....	122.	360.+	sl. s.	s.	s.
11	rhombic, yellow	....	95.	347.	i.	s.	s.
12	monoclinic, need.	1.201(21°)	121.4	249.2	0.2:100 (10°)	s.	s.
13	rhombic prisms	1.24	42.	360.	i.	s.	s.
14	rhombic prisms	....	48.	305.	i.	s.	s.
15	crystals...	....	104.	decomp.	s.	s.	....
16	triclinic, need.	....	85-87.	....	s. h.	....	....
17	long needles	....	161-162.	....	sl. s.	s.	s.
18	monoclin. leaf. w.	....	....	subl.	sl. s.	s.	s.
19	fluid	1.570(15°)	....	217-220.	....	s.	....
20	fluid	1.2122(20°)	....	198.3	decomp.	decomp.	decomp.
21	tablets	....	33.	206-208.	decomp.	....	....
22	fluid	1.057(16°)	....	206.	....	....	....
23	....	1.034(21°)	....	219.	....	s.	....
24	fluid	1.107(14°)	....	176.	i.	s.	s.
25	fluid	1.0146(18°)	....	231.7	i.	s.	....
26	needles	....	....	....	s.	s.	....
27	hex. leaflets	1.011	210.5.	subl.	sl. s.	v. s.	v. s.
28	hex. leaflets	1.011	203-204.	211-212.	sl. s.	v. s.	v. s.
29	rhombohedric	....	50-51.	208.	s.	....	....
30	gas	....	....	....	v. s.	....	....
31	fluid	3.34	....	174.	decomp.	....	....
32	crystals	....	31-31.5	250-251.	....	s.	....
33	crystals	....	18-18.5	251.	....	s.	....
34	rhombic	....	66.4	decomp.	....	s.	....
35	white needles	....	155-156.	....	s. h.	s.	sl. s.
36	leaflets	....	155.3	....	sl. s. h.	v. s.	....
37	tablets	....	189.5	....	v. s. h.	s.	sl. s.
38	....	1.4958(16°)	....	155.	....	s.	....

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Brombenzoic acid (o.)	....	$C_6H_4Br \cdot CO_2H$.......	201.
2	Brombenzoic acid (m.)	....	$C_6H_4Br \cdot CO_2H$.......	201.
3	Brombenzoic acid (p.)	....	$C_6H_4Br \cdot CO_2H$.......	201.
4	Bromoform.......	tribromomethane, methenyl tribromide	$CHBr_3$.............	252.9
5	Bromophenol (o.)..	....	$C_6H_4Br \cdot OH$.........	173.
6	" (m.).	....	$C_6H_4Br \cdot OH$.........	173.
7	" (p.)..	....	$C_6H_4Br \cdot OH$.........	173.
8	Butane..........	....	$CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_3$.	58.1
9	Butyl alcohol (n.).	propylcarbinol.....	$CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_2 (OH)$	74.1
10	" " (sec.).	methylethylcarbinol, butylene hydrate	$(CH_3 \cdot CH_2)CH(OH) CH_3$	74.1.
11	Butyl bromide.....	....	$CH_3 \cdot (CH_2)_2CH_2Br$...	137.
12	chloride (n.).....	....	$CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_2 Cl$	92.5
13	cyanide (n.).....	....	$CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_2 CN$	83.1
14	ether............	....	$(C_4H_9)_2 \cdot O$...........	130.1
15	Butylene.........	....	$CH_3 \cdot CH_2 \cdot CH : CH_2$	56.1
16	Butyric acid......	propylformic acid, ethyl acetic acid	$CH_3 \cdot CH_2 \cdot CH_2 \cdot CO_2H$	88.1
17	aldehyde........	....	$CH_3 \cdot CH_2 \cdot CH_2 \cdot COH$.	72.1
18	anhydride.......	butyryl oxide......	$(C_4H_7O)_2O$..........	158.1
19	Cacodyl..........	....	$(CH_3)_2As \cdot As \cdot (CH_3)_2$.	210.1
20	Cacodylic acid.....	dimethylarsenic acid	$(CH_3)_2AsO \cdot OH$......	138.1
21	Cacodyl oxide.....	....	$((CH_3)_2As)_2O$........	226.1
22	Caffeic acid.......	....	$C_9H_8O_4 + \frac{1}{2}H_2O$......	189.1
23	Caffeine..........	theine, methyltheobromine trimethylxanthine	$C_9H_{10}N_4O_2 + H_2O$.....	212.3
24	Camphor.........	....	$C_{10}H_{16}O$............	152.1
25	Camphoric acid....	....	$C_9H_9(C_2H_5)(CO_2H)_2$..	200.1
26	anhydride.......	....	$C_{10}H_{14}O_3$............	182.1
27	Capric acid.......	caprinic, decylic or decoic acid	$C_9H_{19}(CO_2H)$........	172.2
28	Caproic acid......	capronic, hexoic or pentylformic acid	$C_5H_{11} \cdot CO_2H$........	116.1
29	Caprylic acid......	octoic acid........	$C_7H_{15} \cdot CO_2H$........	144.1
30	Carbanilid........	diphenylurea......	$CO(NH \cdot C_6H_5)_2$......	212.2
31	Carbon disulphide..	....	CS_2...............	76.1
32	hexachloride.....	hexachlorethane, tetrachlorethylenedichloride	C_2Cl_6..............	236.7
33	monoxide........	....	CO................	28.
34	oxysulphide......	....	COS...............	60.1
35	suboxide........	....	$OC : C : CO$.........	68.
36	tetrabromide.....	....	CBr_4...............	331.8
37	tetrachloride.....	....	CCl_4...............	153.8

ORGANIC COMPOUNDS (Continued)

No.	Crystal-line form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	needles	....	150.	....	s.	v. s.	v. s.
2	needles	....	153.	....	sl. s.	v. s.	v. s.
3	needles	....	251.	....	sl. s.	v. s.	v. s.
4	....	1.6606(30°)	7.6	151.2	i.	....	....
5	oil	....	....	194-195.	....	....	....
6	leaflets	....	32-33.	236-236.5	....	....	....
7	gray crystals	1.840	63-64.	235-236.	....	v. s.	v. s.
8	gas	2.046 (air = 1)	....	1.	i.	18: 1 vol.	....
9	fluid	0.8242(0°)	....	116.9	1:12	....	s. HCl
10	fluid	0.827(0°)	....	99.	s.	....	....
11	....	1.2792(20°)	....	105.	....	....	....
12	fluid	1.9074(0°)	....	50.	....	....	....
13	fluid	0.816(15°)	....	78.	....	....	....
14	fluid	0.784(0°)..	....	140.5	....	....	....
15	....	....	....	2.	....	....	....
16	....	0.9624(20°)	−2.	163.	s. a. p.	s. a. p.	s. a. p.
17	fluid	0.9107(0°)	....	75.	1: 27	....	....
18	fluid	0.978(12.6°)	....	191-193.	....	....	....
19	oil	1.+	−6.	170.	sl. s.	s.	s.
20	rhombic prisms	....	200.	....	v. s.	s.	....
21	....	1.462(15°)	−25.	120.	i.	....	....
22	monoclin-ic, yw.	....	195.	decomp.	s.	v. s.	....
23	fine needles	1.23(19°)	234-5	116.subl.	1.35:100	2.3: 100 (85°)	....
24	hexagonal	0.992(15°)	175.	205.	sl. s.	s.	s.
25	monoclin. leaf.	1.193	208.	decomp.	1:12 h.	1: 0.89	i.
26	rhombic prisms	1.94	220-221.	270. decomp.	sl. s.	v. s.	v. s.
27	fine needles	....	30.	260-270.	sl. s.	s.	s.
28	....	0.9438	−2.	205.	sl. s.	....	....
29	leaflets	....	−14.	187.	i.	....	....
30	prisms	....	240.	subl.	sl. s.	s.	....
31	fluid	1.2598(25°)	−110.	46.2	0.1: 100	s. a. p.	s. a. p.
32	rhombic tablets	2.011	184.	....	....	....	....
33	gas	0.9674 (air = 1)	−211.	−190.	3.3cc.: 100g.	20cc.: 100cc.	....
34	....	2.104	....	....	s.	s. a. p.	s. a. p.
35	....	....	....	7	....	....	....
36	tablets	3.42	92.5	189.5	i.	s.	s.
37	....	1.608	−19.5	76.74	sl. s.	v. s.	v. s.

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Carbon tetraiodide		CI_4	519.9
2	Carbonyl chloride		$COCl_2$	98.9
3	Carminic acid		$C_{17}H_{18}O_{10}$	382.2
4	Cellulose		$(C_6H_{10}O_5)x$	162.1
5	Cetyl alcohol	ethal, ethol or palmityl alcohol	$C_{16}H_{34}O$	242.3
6	Chloracetic acid		$CH_2Cl \cdot CO_2H$	94.5
7	Chlor-acetone	monochlorated acetone	$CH_3 \cdot CO \cdot CH_2Cl$	92.5
8	acetyl chloride		$CH_2 \cdot Cl \cdot COCl$	112.9
9	acetylene		C_2HCl	60.5
10	anilin (o.)	anilin chloride	$C_6H_4Cl \cdot NH_2$	127.5
11	" (m.)		$C_6H_4Cl \cdot NH_2$	127.5
12	" (p.)		$C_6H_4Cl \cdot NH_2$	127.5
13	benzamide (o.)		$ClC_6H_4CONH_2$	155.5
14	" (m.)		$ClC_6H_4CONH_2$	155.5
15	" (p.)		$ClC_6H_4CONH_2$	155.5
16	benzene		C_6H_5Cl	112.5
17	ethyl alcohol (2)		$CH_2Cl \cdot CH_2OH$	80.5
18	Chlorhydrine	chloropropylenglycol	$CH_2ClCH(OH)CH_2(OH)$	110.5
19	Chlor-naphthaline (α)		$C_{10}H_7Cl$	162.5
20	" " (β)		$C_{10}H_7Cl$	162.5
21	Chlor-nitrobenzene (o.)		$C_6H_4 \cdot Cl(NO_2)$	157.5
22	" " (m.)		$C_6H_4 \cdot Cl(NO_2)$	157.5
23	" " (p.)		$C_6H_4 \cdot Cl(NO_2)$	157.5
24	Chloral	trichloracetic aldehyde	$CCl_3 \cdot COH$	147.4
25	hydrate	trichloraldehyde hydrate	$CCl_3 \cdot CH(OH)_2$	165.4
26	Chloroform	trichloromethane	$CHCl_3$	119.4
27	Cinnamic acid	betaphenylacrylic acid	$C_6H_5CH : CH \cdot CO_2H$	148.1
28	aldehyde		$C_6H_5CH : CH \cdot CHO$	132.1
29	Cinnamyl alcohol	styrone, styrylic or phenylallylic alcohol	$C_6H_5 \cdot CH : CH \cdot CH_2OH$	134.1
30	Citral	geranial	$C_9H_{15} \cdot CHO$	152.1
31	Citric acid	oxytricarballylic acid	$(CO_2H \cdot CH_2)_2C(OH)CO_2H + H_2O$	210.1
32	Coniferine		$C_{16}H_{22}O_8 + 2H_2O$	378.2
33	Coniine	conicine, dextroalphapropylpiperidine	$C_8H_{17}N$	127.2
34	Coumaric acid (o.)		$OHC_6H_4CH : CH \cdot CO_2H$	164.1
35	" " (p.)		$OHC_6H_4CH : CH \cdot CO_2$	164.1
36	Coumarin	cumarin, tonkabean camphor	$C_9H_6O_2$	146.1
37	Creatine	methylglycocyamine	$C_4H_7N_3O_2 + H_2O$	149.2
38	Creatinine	dehydrated creatine	$C_4H_7N_3O$	113.2
39	Creosole	homoguaiacol, homopyrocatecholmonomethylester	$CH_3 \cdot OC_6H_3(CH_3)OH$	138.1
40	Cresol (o.)	cresylic acid (o.)	$CH_3 \cdot C_6H_4OH$	108.1
41	" (m.)	" " (m.)	$CH_3 \cdot C_6H_4OH$	108.1
42	" (p.)	" " (p.)	$CH_3 \cdot C_6H_4OH$	108.1
43	Crotonic acid (α)		$CH_3 \cdot CH : CH \cdot CO_2H$	86.1
44	" " (β)		$CH_3 \cdot CH : CH \cdot CO_2H$	86.1

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in Water	Solubility in Alcohol	Solubility in Ether
1	regular, red.	4.32	....	decomp.	....	....	....
2	....	1.392	....	8.2	decomp.	decomp.	....
3	red	....	....	....	s. h.	i.	i.
4	amorphous	1.525	....	....	i.	i.	i.
5	crystals	0.8176(49°)	50.	344.	i.	s.	s.
6	rhombic tablets	....	62.	185-187.	v. s.	s.	s.
7	fluid	1.162	....	119.	sl. s.	s. a. p.	s. a. p.
8	....	1.495	....	105-106.	....	....	....
9	gas	....	....	....	....	....	....
10	fluid	1.234(0°)	-14.	207.	....	....	....
11	fluid	1.243(0°)	....	230.	....	....	....
12	white prisms	....	71.	231.	....	....	....
13	long, white need.	....	142.4	....	sl. s.	v. s.	v. s.
14	needles	....	132-133.	....	sl. s.	v. s.	....
15	needles	....	178.3	....	sl. s.	v. s.	v. s.
16	....	1.106	-40.	132.	....	s.	....
17	....	1.2233	....	130-131.	s.a.p.	s. a. p.	s. a. p.
18	fluid	1.139(15°)	....	127.	s.	s.	s.
19	fluid (6.4°)	1.2028	....	250-252.	....	s.	....
20	....	1.2656(16°)	56.	264-266.	....	s.	....
21	needles	1.368(23°)	32.5	243.	i.	s.	....
22	rhombic	1.534	44.4	235.6	i.	s. h.	....
23	rhombic leaflets	1.380(20°)	83.	242.	i.	s.	....
24	fluid	1.512(20°)	....	96.	s.	s.	....
25	....	1.5771(66°)	57.	97.5	s.	s.	s. CS_2
26	fluid	1.526	-70.	61.	i.	s.	s.
27	monoclinic prisms	1.475(4°)	133.	300.	sl. s.	s.	v. s.
28	....	1.0497	-7.5	220-225.	....	s.	....
29	long needles	1.0440	33.	254.	s.	v. s.	v. s.
30	....	0.885	....	225.	i.	....	....
31	rhombic prisms	1.542	153.	decomp.	v. s.	s.	s.
32	needles	....	185.	decomp.	s. h.	s.	i.
33	fluid	0.88	....	167.	sl. s.	v. s.	v. s.
34	large needles	....	207-208.	decomp.	s. h.	s.	....
35	needles	....	206.	....	....	....	....
36	rhombic	....	67.	291.subl.	sl. s.	s.	s.
37	monoclinic prisms	....	decomp.	....	s.	sl. s.	i.
38	monoclinic prisms	....	decomp.	....	s.	sl. s.	....
39	fluid	1.0894	....	219.	sl. s.	s. a. p.	s. a. p.
40	crystals	1.039(23°)	31-31.5	190.	sl. s.	s.	s.
41	fluid	1.033(19°)	....	202.8	sl. s.	s.	s.
42	prisms	1.033(23°)	33.5	201.8	sl. s.	s.	s.
43	needles	1.018	72.	182.	1:12(15°)	....	....
44	fluid	1.108	15.	172.	s. a. p.	....	....

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Crotonic aldehyde (α)	....	$CH_3 \cdot CH:CH \cdot CHO$...	70.1
2	Cumene..........	isopropylbenzene...	$C_6H_5CH \cdot (CH_3)_2$.....	120.1
3	Cuminic acid......	isopropylbenzoic acid	$C_6H_4(C_3H_7)CO_2H$....	164.1
4	aldehyde........	cuminol..........	$C_6H_4 \cdot (C_3H_7) \cdot COH$...	148.1
5	Cyan-acetic acid...	....	$CH_2 \cdot CN \cdot CO_2H$......	85.1
6	amide...........	....	$NC \cdot NH_2$...........	42.1
7	anilid...........	....	$CN \cdot NH \cdot C_6H_5$.......	118.1
8	Cyanic acid.......	....	CONH.............	43.1
9	Cyanogen.........	....	$(CN)_2$..............	52.1
10	bromide.........	....	CNBr..............	106.
11	chloride.........	....	CNCl..............	61.5
12	Cyan-propionic acid (α)	....	$CH_3 \cdot CH(CN) \cdot CO_2H$.	99.1
13	Cyanuric acid.....	....	$C_3N_3H_3O_3+2H_2O$....	165.2
14	Decane...........	diamyl...........	$CH_3 \cdot (CH_2)_8CH_3$.....	142.2
15	Decyl alcohol.....	....	$CH_3 \cdot (CH_2)_8 \cdot CH_2OH$.	158.2
16	Dextrin...........	....	$C_6H_{10}O_5$.............	162.1
17	Diacetyl..........	....	$CH_3 \cdot CO \cdot CO \cdot CH_3$...	86.1
18	Diazo-amino-benzene	benzeneazoanilin...	$C_6H_5 \cdot N_2 \cdot NH \cdot C_6H_5$...	197.2
19	benzene chloride..	....	$C_6H_5 \cdot N_2 \cdot Cl$.........	140.6
20	" nitrate...	....	$C_6H_5 \cdot N_2 \cdot NO_3$.......	167.2
21	" sulphonic acid (o.)	....	$C_6H_4:N_2SO_3$........	184.2
22	benzene sulphonic acid (m.)	....	$C_6H_4:N_2SO_3$........	184.2
23	benzene sulphonic acid (p.)	....	$C_6H_4:N_2SO_3$........	184.2
24	Dibrom-acetic acid.	....	$CHBr_2 \cdot CO_2H$.......	217.9
25	benzene (o.).....	....	$C_6H_4Br_2$.............	236.
26	" (m.).....	....	$C_6H_4Br_2$.............	236.
27	" (p.).....	....	$C_6H_4Br_2$.............	236.
28	Dichlor-acetic acid.	....	$CHCl_2 \cdot CO_2H$........	128.9
29	acetyl chloride...	....	$CHCl_2 \cdot COCl$.........	147.4
30	anthracene (β)...	....	$C_{14}H_8Cl_2$............	247.
31	anilin (2, 4)......	....	$C_6H_3 \cdot Cl_2 \cdot NH_2$.......	162.
32	" (2, 5)......	....	$C_6H_3 \cdot Cl_2 \cdot NH_2$.......	162.
33	" (3, 4)......	....	$C_6H_3 \cdot Cl_2 \cdot NH_2$.......	162.
34	" (3, 5)......	....	$C_6H_3 \cdot Cl_2 \cdot NH_2$.......	162.
35	benzene (o.).....	....	$C_6H_4Cl_2$.............	146.9
36	" (m.).....	....	$C_6H_4Cl_2$.............	146.9
37	" (p.).....	....	$C_6H_4Cl_2$.............	146.9
38	hydrine (1, 3)....	alphapropenyl dichlorhydrin	$CH_2Cl \cdot CH(OH) \cdot CH_2Cl$	129.
39	" (2, 3)....	....	$CH_2Cl \cdot CH(OH) \cdot CH_2Cl$	129.
40	propane (2, 2)....	....	$CH_3 \cdot CCl_2 \cdot CH_3$......	113.

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O = 1$	Melting-point °C	Boiling-point °C	Solubility in Water	Solubility in Alcohol	Solubility in Ether
1	fluid	1.033(0°)	....	104-105.	s.	....	....
2	fluid	0.88(0°)	....	152.	i.	s.	s.
3	prisms	1.16	114.	subl.	s. h.	s.	s.
4	....	0.9727(13°)	....	235.	....	....	....
5	crystals	....	65.	decomp.	s.	....	s.
6	crystals	....	40.	....	s. h.	s.	s.
7	needles	....	47.	....	sl. s.	s.	s.
8	....	1.14(0°)	....	....	s.	....	....
9	gas	1.804 (Air = 1)	−34.4	−20.7	450:100 vol.	....	....
10	needles	....	52.	61.3	....	....	....
11	....	1.+	−5.	15.5	s.	s.	s.
12	yellow, amorphous	....	140. decomp.	....	s.	s.	....
13	monoclinic	1.768(0°)	....	....	sl. s.	sl. s.	....
14	....	0.730(20°)	−30 to −32.	173.	....	....	....
15	liquid	0.8297	7.	231.	....	s.	....
16	amorphous	1.03845	....	....	s.	i.	....
17	....	....	....	88.	....	....	....
18	yellow leaflets	....	98.	expl.	i.	s.	s.
19	needles	....	....	....	s.	sl. s.	....
20	yellow needles	....	expl.	....	v. s.	sl. s.	i.
21	crystalline mass	....	....	....	....	....	....
22	red prisms	....	decomp.	....	decomp.	....	....
23	needles	....	....	....	i., c.; s. 60°; dec. h.	i.	
24	crystals	....	48.	232-234.	v. s.	v. s.	v. s.
25	....	2.003(0°)	−1.	225.	....	s.	....
26	fluid	1.955(19°)	−1.	220.	....	s.	s.
27	monoclinic prisms	2.22	89.	219.	....	s.	....
28	....	....	−4.	190.	....	....	....
29	....	....	....	107-108.	....	....	....
30	large yellow need.	....	209.	....	s. benzene	sl. s.	sl. s.
31	needles	....	63.	245.	....	s.	....
32	large needles	....	50.	....	....	s.	....
33	needles	....	71.5	272.	....	s.	....
34	needles	....	50.5	....	....	s.	....
35	fluid	1.3278	−14.	179.	....	s.	....
36	....	1.307	−18.	172.	....	s.	....
37	monoclinic leaf.	1.458(20°)	53.	172.	s. benzene	v. s.	v. s.
38	fluid	1.367	....	182.	sl. s.	....	....
39	fluid	1.355	....	182.	....	....	....
40	....	1.827(16°)	....	69.7	....	....	....

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Diethyl-acetic acid.	....	$(C_2H_5)_2HC\cdot CO_2H$....	116.1
2	amine...........	....	$(C_2H_5)_2NH$..........	73.1
3	carbinol.........	amyl-alcohol (sec.).	$(C_2H_5)_2CHOH$.......	88.1
4	ketone..........	metacetone, propione, ethylpropionyl	$(C_2H_5)_2CO$..........	86.1
5	Dihydroxy-benzoic acid (2, 3)	....	$(OH)_2C_6H_3CO_2H+2H_2O$	190.1
6	benzoic acid (2, 4).	....	$(OH)_2C_6H_3CO_2H+3H_2O$	208.1
7	" " (2, 5).	....	$(OH)_2C_6H_3CO_2H$.....	154.1
8	" " (3, 5).	....	$(OH)_2C_6H_3CO_2H+1\frac{1}{2}H_2O$	181.1
9	benzophenone (2,4)	....	$(C_6H_4OH)_2CO$.......	214.1
10	benzophenone (3,3)	....	$(C_6H_4OH)_2CO$.......	214.1
11	benzophenone (4, 4)	....	$(C_6H_4OH)_2CO$.......	214.1
12	Dimethyl amine....	....	$(CH_3)_2NH$..........	45.1
13	anilin...........	phenyldimethylamine	$C_6H_5\cdot N(CH_3)_2$.......	121.1
14	anthracene (α)...	....	$CH_3\cdot C_6H_3(C_2H_2)C_6H_3\cdot CH_3$	206.
15	benzoic acid (2, 3).	....	$(CH_3)_2C_6H_3\cdot CO_2H$....	150.1
16	" " (3, 4).	....	$(CH_3)_2C_6H_3\cdot CO_2H$...	150.1
17	" " (2, 4).	....	$(CH_3)_2C_6H_3\cdot CO_2H$...	150.1
18	" " (2, 6).	....	$(CH_3)_2C_6H_3\cdot CO_2H$...	150.1
19	" " (2, 5).	....	$(CH_3)_2C_6H_3\cdot CO_2H$...	150.1
20	Dinitro-benzene (o.)	....	$C_6H_4(NO_2)_2$.........	168.1
21	benzene (m.).....	....	$C_6H_4(NO_2)_2$.........	168.1
22	" (p.).....	....	$C_6H_4(NO_2)_2$.........	168.1
23	phenol (2, 3).....	....	$C_6H_3(NO_2)_2OH$......	184.1
24	" (2, 4).....	....	$C_6H_3(NO_2)_2OH$......	184.1
25	" (2, 6).....	....	$C_6H_3(NO_2)_2OH$......	184.1
26	toluene (2, 4)....	....	$C_6H_3(NO_2)_2CH_3$......	182.1
27	" (3, 4)....	....	$C_6H_3(NO_2)_2CH_3$......	182.1
28	" (3, 5)....	....	$C_6H_3(NO_2)_2CH_3$......	182.1
29	Diphenyl amine...	phenylanilin.......	$(C_6H_5)_2NH$..........	169.1
30	hydrazine.......	monoamidodiphenylamine hydrochloride	$(C_6H_5)_2N\cdot NH_2$......	184.2
31	urea............	carbanilid.........	$NH_2\cdot CO\cdot N(C_6H_5)_2$...	212.2
32	Dipropyl carbinol..	....	$(C_3H_7)_2CHOH$.......	116.1
33	ketone..........	butyrone.........	$(C_3H_7)_2CO$..........	114.1
34	Dodecane.........	....	$C_{12}H_{26}$..............	170.2
35	Eosine............	tetrabromofluorescein	$C_{20}H_8Br_4O_5$..........	647.9
36	Erythrite.........	erythroglucin, phycite	$C_4H_6(OH)4$.........	122.1
37	Ethane...........	....	$CH_3\cdot CH_3$..........	30.1
38	Ether............	ethyl oxide, ethylic or sulphuric ether	$C_2H_5\cdot O\cdot C_2H_5$.......	74.1
39	Ethyl acetate.....	acetic ether.......	$CH_3\cdot CO_2(C_2H_5)$......	88.1
40	acetoacetate.....	diacetic ether......	$CH_3CO\cdot CH_2\cdot CO_2\cdot C_2H_5$	130.1

ORGANIC COMPOUNDS (Continued)

No.	Crystal-line form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	....	0.9196	−15.	190.	sl. s.	....	.....
2	fluid	....	....	57.	s.	s.	.....
3	....	0.8312(0°)	....	116.5 (753 mm)	....	....	.....
4	....	0.829(0°)	....	103.	1:24	....	.....
5	needles	....	204.	decomp.	s.	....	.....
6	needles	....	204-206. dec.	decomp.	sl. s.	v. s.	v. s.
7	needles or prisms	....	199-200.	decomp.	s. h.	v. s.	v. s.
8	needles or prisms	....	232-233.	....	s.	v. s.	v. s.
9	pyramidal	....	143-144.	....	sl. s. h.	....	v. s.
10	small needles	....	162-163.		s.	s.	.....
11	yellow needles	....	210.	....	v. s. h.	v. s.	v. s.
12	fluid	....	....	8-9.	s.	s.	.....
13	....	0.9553	0.5	192.	....	s.	.....
14	....	....	246.	....	i.	s.	s.
15	prisms	....	144.	....	v. s. h.	s.	.....
16	prisms	....	163.	....	v. sl. s.	v. sl. s.	.....
17	monoclinic prisms	....	126.	268.	v. sl. s.	s.	s.
18	short needles	....	116.	....	sl. s.	....	.....
19	long needles	....	132.	268.	sl. s. h.	v. s.	.....
20	monoclinic needles	....	117.9	....	sl. s. h.	3.8 : 100	.....
21	rhombic	1.369	90.	297.	i.	sl. s.	.....
22	monoclinic needles	....	172.	subl.	s. h.	s. h.	.....
23	yellow needles	....	144.	....	sl. s.	s.	v. s.
24	yellow tablets	....	113-114.	....	sl. s.	s.	v. s.
25	yellow needles	....	61.78	....	sl. s.	s.	v. s.
26	monoclin-ic, long need.	....	70.5	....	i.	sl. s.	sl.s.CS_2
27	needles	1.32	60.	....	i.	s.	s..s.CS_2
28	needles	....	92-93.	....	sl. s.	s.	s.
29	monoclinic leaf.	1.858	54.	310.	sl. s.	s.	s.
30	yellow	....	44.	220.	sl. s.	s.	s.
31	needles	....	189.	....	....	....	.....
32	....	0.820(20°)	....	154.	....	s.	s.
33	fluid	0.82(20°)	....	144.	i.	....	.....
34	....	0.7655(0°)	−12.	214.	....	....	.....
35	yw. r. tricl. need.	....	....	....	v. sl. s.	s.	.....
36	tetrag., prisms	1.452(17°)	126.	330.	v. s.	sl. s.	i.
37	gas	1.036 (A = 1)	−171.4	−85.4 (749mm)	....	46 : 100 vol.	.....
38	fluid	0.7183(17°)	−112.6	34.97	sl. s.	s. a. p.	s. a. p.
39	fluid	0.9238	−82.	77.	7.8 : 100	s. a. p.	s. a. p.
40	....	1.0282(20°)	−80.	181.	sl. s.	....	.....

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Ethyl acetylene		$C_2H_5C_2H$	54.1
2	alcohol		$C_2H_5 \cdot OH$	46.1
3	amine		$C_2H_5 \cdot NH_2$	45.1
4	benzoate	benzoic ether	$C_6H_5 \cdot CO_2(C_2H_5)$	150.1
5	borate		$(C_2H_5)_3BO_3$	146.1
6	bromide	mononbromethane, hydrobromic ether	C_2H_5Br	109.
7	butyrate	butyric ether	$C_3H_7 \cdot CO_2(C_2H_5)$	116.1
8	carbonate	carbonic or diethyl-carbonic ether	$CO(C_2H_5O)_2$	118.1
9	chloride	monochlorethane, kelene	C_2H_5Cl	64.5
10	cinnamate	cinnamic ether	$C_6H_5 \cdot C_2H_2CO_2 \cdot C_2H_5$	176.1
11	cyanide	propoinitrile, hydrocyanic ether	$C_2H_5 \cdot CN$	55.1
12	disulphide		$(C_2H_5)_2S_2$	122.2
13	formate	formic ether	$HCO_2 \cdot C_2H_5$	74.1
14	hydrazine		$C_2H_5 \cdot NH \cdot NH_2$	60.1
15	hydroxylamine		$NH_2 \cdot (C_2H_5)O$	61.1
16	iodide	hydriodic ether, monoiodoethane	C_2H_5I	156.
17	isocyanate		$CNO \cdot C_2H_5$	71.1
18	isocyanide	ethylcarbylamine	$C_2 \cdot H_5 \cdot NC$	55.1
19	malonate	malonic ether	$(C_2H_5)_2 \cdot C_3H_2O_4$	160.1
20	mercaptan		$C_2H_5 \cdot SH$	62.1
21	mustard oil	ethyl thiocarbimide	$C_2H_5 \cdot NCS$	87.1
22	nitrate	nitric ether	$C_2H_5 \cdot NO_3$	91.1
23	nitrite	nitrous ether	$C_2H_5 \cdot ONO$	75.1
24	oxalate	oxalic ether	$(C_2H_5)_2 \cdot C_2O_4$	146.1
25	phosphate		$(C_2H_5)_3 \cdot PO_4$	182.1
26	propionate	propionic ether	$C_2H_5 \cdot CO_2 \cdot C_2H_5$	102.1
27	salicylate	salicylic ether	$HOC_6H_5 \cdot CO_2 \cdot C_2H_5$	166.1
28	succinate	succinic ether	$C_4H_4O_4(C_2H_5)_2$	174.1
29	sulphate		$SO_2(O \cdot C_2H_5)_2$	154.2
30	sulphide	diethyl sulphide	$C_2H_5 \cdot S \cdot C_2H_5$	90.2
31	sulphonic acid		$C_2H_5 \cdot SO_2 \cdot OH$	110.1
32	sulphuric acid		$C_2H_5 \cdot HSO_4$	126.1
33	urea		$CO \cdot NH_2 \cdot NH(C_2H_5)$	88.1
34	Ethylene	ethene, olefiant gas	$CH_2 : CH_2$	28.
35	bromide	dibromethane	$C_2H_4Br_2$	188.
36	chloride	dichlorethane, Dutch liquid	$C_2H_4Cl_2$	98.9
37	diamine		$C_2H_4(NH_2)_2+H_2O$	78.2
38	nitrate		$C_2H_4(NO_2)_2$	152.1
39	nitrate nitrite		$NO_2 \cdot CH_2 \cdot CH_2 \cdot NO_3$	136.1

ORGANIC COMPOUNDS (Continued)

No.	Crystal-line form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in Water	Solubility in Alcohol	Solubility in Ether
1	fluid	....	....	18.	....	....	....
2	fluid	0.8002(0°)	-112.	78.4	s. a. p.	....	s. a. p.
3	fluid	0.696	....	18.7	s. a. p.	s. a. p.	s. a. p.
4	fluid	1.657	....	213.4	sl. s. h.	s.	s.
5	....	0.887	....	120.	....	....	....
6	fluid	1.47(0°)	....	38.4	sl. s.	s. a. p.	s. a. p.
7	fluid	0.902	....	119.	0.5 : 100	s.	s.
8	fluid	0.978(20°)	....	125.8	i.	s.	....
9	fluid	0.92295(15°)	....	19.5	2 : 100	s. a. p.	s. a. p.
10	....	1.066	12.	271.	....	s.	....
11	....	0.801(0°)	....	98.	s.	....	....
12	....	0.993(20°)	....	151.	v. sl. s.	....	....
13	....	0.938	....	54.4	11 : 100	s. a. p.	s. a. p.
14	....	....	....	100.	v. s.	v. s.	s.
15	....	0.88(7.5°)	....	58.	s. a. p.	s. a. p.	s. a. p.
16	fluid	1.944(15°)	....	72.2	sl. s.	s.	s.
17	....	0.8981	....	60.	i.	....	....
18	....	0.7591	-60. (?)	78.1	s.	....	s.
19	....	1.061	-49.8	198.	....	....	....
20	....	0.835	-144.	36.2	1.5:100	s.	....
21	fluid	1.019(0°)	....	133.	i.	s.	s.
22	....	1.1123(15°)	....	86.3	....	s.	....
23	....	0.9(15°)	....	17.	....	s.	....
24	fluid	1.0793(20°)	....	186.	sl. s.	s.	....
25	....	1.072	....	215.	decomp.	s.	s.
26	....	0.896	....	98.8	sl. s.	s. a. p.	s. a. p.
27	....	1.184	....	231.5	....	....	....
28	....	1.046	-21.	216.5	i.	sl. s.	i.
29	....	1.184	....	208.	i.	decomp. h.	....
30	fluid	0.8367	....	92.	i.	....	....
31	crystals	....	....	....	v. s.	s.	....
32	....	1.316(16°)	....	decomp.	s.	s.	....
33	....	....	92.	decomp.	s.	s.	....
34	gas	0.978 (Air=1)	-160.	-103.	1 : 8vol.	2 : 1	2 : 1
35	....	2.178(20°)	9.5	132.	i.	s.	....
36	fluid	1.28	....	83.5	i.	s.	....
37	....	0.97(15°)	10.	116.	s.	....	....
38	fluid	1.472	....	decomp.	....	s.	....
39	oil	1.472	....	....	....	s.	....

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Ethylene nitrite		$C_2H_4(NO_2)_2$	120.1
2	oxide		$C_2H_4O_0$	44.
3	Eucalyptol	cineol	$C_{10}H_{18}O$	154.2
4	Eugenol	eugenic or caryophyllic acid, paraoxymetamethoxyallylbenzene	$C_6H_3(OH)(OCH_3)$ $CH_2 \cdot CH:CH_2$	164.1
5	Fluorescein	resorcinolphtalein, tetraoxyphtalophenonanhydride	$C_{20}H_{12}O_5$	332.1
6	Fluoroform		CHF_3	70.
7	Formic acid	methanoic acid	$H \cdot CO_2H$	46.
8	Formaldehyde	oxymethylene	$H \cdot CHO$	30.
9	Fructose	levulose, fruit sugar	$C_6H_{12}O_6$	180.1
10	Fulminic acid		$C_2H_2N_2O_2$	86.1
11	Fumaric acid	allomaleic acid	$CO_2H \cdot CH:CH \cdot CO_2H$	116.
12	Furfural	furfuraldehyde, artificial oil of ants	$C_4H_3O \cdot COH$	96
13	Galactose (d.)	lactogluctose	$C_6H_{12}O_6$	180.1
14	Gallic acid (3, 4, 5)	trihydroxybenzoic acid	$C_6H_2(OH)_3 \cdot CO_2H + H_2O$	188.1
15	Geraniol		$C_{10}H_{18}O$	154.2
16	Gluconic acid	dextronic, maltonic or pentahydroxycaproic acid	$C_5H_6(OH)_5CO_2H$	196.1
17	Glucose (d.)	dextrose, grape sugar	$C_6H_{12}O_6 + H_2O$	198.1
18	Glutaric acid	normal pyrotartaric acid	$(CH_2)_3(CO_2H)_2$	132.1
19	Glyceric acid	dioxypropionic acid	$CH_2(OH)CH(OH)$ CO_2H	106.1
20	aldehyde		$CH_2OH \cdot CHOH \cdot COH$	90.1
21	Glycerine	glycyl or propenyl alcohol	$C_3H_5(OH)_3$	92.1
22	mononitrate	nitroglycerine (α mono-)	$C_3H_5(OH)_2(ONO_2)$	137.1
23	trinitrate	nitroglycerine (tri-)	$C_3H_5(ONO_2)_3$	227.2
24	Glycocholic acid	cholic acid	$C_{26}H_{43}NO_6$	465.4
25	Glycocoll	glycin, aminoacetic acid	$NH_2CH_2CO_2H$	75.1
26	Glycogen		$(C_6H_{10}O_5)x$	162.1
27	Glycol	ethylene glycol	$C_2H_4(OH)_2$	62.1
28	Glycollic acid	oxyacetic acid	$CH_2 \cdot OH \cdot CO_2H$	76.
29	Glycollid		$C_2H_2O_2$	58.
30	Glycol urea		$C_3H_4N_2O_2$	100.1
31	Glyoxal		$CHO \cdot CHO$	58.
32	Glyoxime		$(CH:NOH) \cdot (CH:NOH)$	88.1
33	Guaiacol	monomethylcatechol	$C_6H_4(OH)OCH_3$	124.1
34	Guanine	imidoxanthine	$C_5H_5N_5O$	151.1
35	Heptane (n.)	heptyl hydride, methyl hexane, dipropylmethane	$CH_3 \cdot (CH_2)_5 \cdot CH_3$	100.2
36	"	dimethyldiethylmethane	$(CH_3)_2 \cdot C \cdot (C_2H_5)_2$	100.2
37	"	triethylmethane	$CH \cdot (C_2H_5)_3$	100.2
38	"	ethyl-amyl	$CH_3(CH_2)_3 \cdot CH(CH_3)_2$	100.2

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O = 1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	prisms	....		97.	i.	s.	s.
2	fluid	0.896(0°)	....	13.5	v. s.	v. s.	v. s.
3	....	0.92	−1.	176.	decomp.	....	....
4	fluid	1.0779(0°)	....	247.5	sl. s.	s.	s.
5	red crystals	....	decomp.	....	sl. s.	s.	s.
6	gas	....	....	20. (40 atm.)	....	....	....
7	....	1.2448(0?)	8.6	100.8	s. a. p.	....	....
8	gas	1.6(Air = 1)	−92.	−21.	s.	s.	....
9	....	....	95.	100. decomp.	s.	....	....
10	....	....	....	....	....	....	v. s.
11	prisms, need. leaf.	....	....	....	sl. s.	s.	s.
12	fluid	1.165(16°)	....	162.	1 : 11	s.	s.
13	rhombic	....	170.	....	sl. s.	v. sl. s.	....
14	triclinic need.	1.70(4°)	222.	decomp.	33:100h.	s.	s.
15	....	0.8829(15°)	−15.	229-230.	i.	s. a. p.	s. a. p.
16	syrup	....	....	....	v. s.	i.	....
17	microscopic tabl.	1.56(11°)	146.	....	98 : 100 (18°)	....	....
18	....	....	91.	299.	1:1.5	s.	s.
19	fluid	....	....	....	s. a. p.	s. a. p.	i.
20	....	....	138.	....	sl. s.	v. sl. s.	v. sl. s.
21	rhombic	1.26(20°)	17.	290.	s.	s.	i.
22	....	1.40	58.	155-160. (15 mm.)	70 : 100	....	....
23	....	1.6	12.2	260 expl.	0.16:100	s.	s.
24	needles	....	152.	....	3. 3 :100	s.	sl. s.
25	monoclinic	1.1607	232-236.	....	23.2:100	i.	....
26	amorphous powder	....	240. appr.	....	v. s.	i.	....
27	fluid	1.25(0°)	....	197.5	s. a. p.	s. a. p.	....
28	needles or leaf.	....	79.	decomp.	s. a. p.	s. a. p.	s. a. p.
29	powder	....	86.	....	i. c.; sl. s. h.	....	....
30	needles	....	216.	....	s.	....	....
31	amorphous	....	15. decomp.	....	v. s.	v. s.	s.
32	tablets	....	178.	subl.	s.	s.	s.
33	rhombic prisms	1.12	31-32.	205.	sl. s.	s.	s.
34	amorphous powder	....	decomp.	....	v. sl. s.	v. sl. s.	v. sl. s.
35	fluid	0.712(16°)	....	97-97.5	....	s.	s.
36	fluid	0.711(0°)	....	86.7	....	s.	s.
37	fluid	0.689(27°)	....	96.	....	s.	s.
38	fluid	0.6833(18°)	....	90.5	....	s.	s.

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Hexabrom ethane		$CBr_3 \cdot CBr_3$	403.8
2	Hexachlor benzene		C_6Cl_6	284.7
3	ethane	carbon hexachloride	C_2Cl_6	236.7
4	Hexahydroxybenzene		$C_6(OH)_6$	174.1
5	Hexamethyl benzene		$C_6(CH_3)_6$	162.2
6	Hexane (n.)	hexyl or caproyl hydride	$CH_3 \cdot (CH_2)_4 \cdot CH_3$	86.1
7	"	diisopropyl	$(CH_3)_2 \cdot CH \cdot CH \cdot (CH_3)_2$	86.1
8	"	ethylisobutyl	$CH_3(CH_2)_2 \cdot CH \cdot (CH_3)_2$	86.1
9	Hippuric acid	benzoylglycin, benzaminoacetic acid	$C_6H_5 \cdot CO \cdot HN \cdot CH_2 \cdot CO_2H$	179.1
10	Hydroazo-benzene		$C_6H_5 \cdot NH \cdot NH \cdot C_6H_5$	184.2
11	benzoic acid (o.)		$(NH \cdot C_6 \cdot H_4 \cdot CO_2H)_2$	272.2
12	" " (m.)		$(NH \cdot C_6 \cdot H_4 \cdot CO_2H)_2$	272.2
13	" " (p.)		$(NH \cdot C_6 \cdot H_4 \cdot CO_2H)_2$	272.2
14	Hydrocinnamic acid	benzylacetic, beta-phenylpropionic, or homotoluylic	$C_6H_5 \cdot CH_2 \cdot CH_2CO_2H$	150.1
15	aldehyde		$C_6H_5(CH_2)_2CHO$	134.1
16	Hydrocyanic acid	Prussic acid, formonitrile	HCN	27.1
17	Hydroquinone (p.)	quinol, paradioxybenzene	$C_6H_4(OH)_2$	110.1
18	Indigo	indigotin	$C_6H_4 < {CO \atop NH} > C : C < {CO \atop NH} > C_6H_4$	262.2
19	disulphonic acid	soluble indigo blue	$C_{16}H_8N_2O_2(SO_3H)_2$	422.3
20	sulphonic acid	indigo monosulphonic acid	$C_{16}H_9N_2O_2(SO_3H)$	342.2
21	white		$C_{16}H_{12}N_2O_2$	264.2
22	Indol	indole, ketole	C_8H_7N	117.1
23	Indoxyl		C_8H_6NOH	133.1
24	Inulin	dahlin, alantin	$(C_6H_{10}O_5)N + H_2O$	990.1
25	Iodoform	triiodomethane	CHI_3	393.8
26	Isoamyl-acetate		$C_2H_3O_2 \cdot C_5H_{11}$	130.1
27	alcohol	fusel oil	$(CH_3)_2CH \cdot (CH_2)_2OH$	88.1
28	" (sec.)		$(CH_3)_2 \cdot CH \cdot CH(OH) \cdot CH_3$	88.1
29	chloride		$C_5H_{11}Cl$	106.5
30	cyanide		$(CH_3)_2CH(CH_2)_2CN$	97.1
31	isocyanide		$(CH_3)_2CH(CH_2)_2CN$	97.1
32	mustard oil		$C_5H_{11}N \cdot CS$	129.2
33	Isobutyl-acetate		$C_2H_3O_2 \cdot C_4H_9$	116.1
34	alcohol	isopropylcarbinol	$(CH_3)_2 \cdot CH \cdot CH_2 \cdot OH$	74.1
35	chloride		$(CH_3)_2 \cdot CH \cdot CH_2Cl$	92.5
36	cyanide		$(CH_3)_2 \cdot CH \cdot CH_2CN$	83.1
37	mustard oil		$(CH_3)_2 \cdot CH \cdot CH_2NCS$	115.2
38	Isobutyric acid	isopropylformic acid	$CH(CH_3)_2CO_2H$	88.1
39	Isoprene		C_5H_8	68.1

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	prisms	....	....	251. decomp.	....	sl. s.	sl. s.
2	prisms	1.4624(306°)	229.	326.	....	i. c.	v. sl. s.
3	rhombic tablets	2.011	....	182.	i.	s.	s.
4	long needles	....	....	....	sl. s.	sl. s.	sl. s.
5	rhombic tablets	....	163.	264.	....	sl. s.	....
6	fluid	0.663(17°)	....	71.5	....	s.	s.
7	fluid	0.67(17°)	....	58.	....	s.	s.
8	fluid	0.7011(0°)	....	62.	....	s.	s.
9	rhombic	....	....	decomp.	s. h.	s.	sl. s.
10	colorless tablets	....	131.	decomp.	i.	s.	s.
11	leaflets	....	205.	....	....	s. h.	....
12	yellow crystals	....	....	....	i.	sl. s. h.	....
13	small needles	....	....	....	i.	sl. s.	(s.KOH)
14	monoclinic prisms	1.0711(49°)	48.7	279.8	sl. s.	v. s.	s.
15	moniclinic prisms	....	....	208.	....	....	....
16	....	0.6969(18°)	−14.	26.1	s. a. p.	s. a. p.	s. a. p.
17	rhombohedric or monoclinic	1.32	169.	subl.	1 : 17	s.	s.
18	blue crystals	1.35	subl.	....	i.	i.	i.
19	blue, amorphous	....	....	....	s.	s.	....
20	purple	....	....	200. decomp.	s.	s.	....
21	white mass	....	....	....	i.	s.	s.
22	leaflets	....	52.	245.	sl. s. h.	s. h.	s.
23	oil	....	....	not volatil	(s. alk.)	....	....
24	fine crystals	1.3491 (anhy.)	160. decomp.	....	sl. s.	sl. s.	....
25	hexagonal. yellow	4.09	119.	subl. decomp.	i.	s.	s.
26	....	0.8762	....	139.	s.	s. a. p.	s. a. p.
27	fluid	0.825(0°)	....	129.	1: 39	s.	s.
28	fluid	0.829(0°)	....	112.5	....	....	....
29	fluid	0.875(15°)	....	102.	i.	s.	....
30	....	0.8061(20°)	....	155.	....	....	....
31	....	....	....	137.	i.	s.	....
32	fluid	0.9419(17°)	....	183-184.	....	....	....
33	....	0.8921(0°)	....	116.3	sl. s.	s. a. p.	s. a. p.
34	monoclinic prisms	0.8031(20°)	fluid	108.4	1: 10	....	....
35	fluid	0.8953(0°)	....	69.	....	....	....
36	fluid	0.8227(0°)	....	129.	sl. s.	....	....
37	fluid	0.9638(14°)	....	162.	....	....	....
38	....	0.9519(20°)	−79.	155.5	1 : 5	....	....
39	....	0.6823(20°)	....	37.	....	....	....

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Isopropyl-acetate		$CH_3CO_2 \cdot CH(CH_3)_2$	102.1
2	alcohol	secondary propyl alcohol	$(CH_3)_2CH \cdot OH$	60.1
3	cyanide		$(CH_3)_2 \cdot CH \cdot CN$	69.1
4	isocyanide	isopropylcarbylamine	$(CH_3)_2 \cdot CH \cdot CN$	69.1
5	Lactic acid	alphahydroxypropionic or ethylidenelactic acid	$CH_3 \cdot CH \cdot (OH)CO_2H$	90.1
6	anhydride		$C_6H_{10}O_5$	162.1
7	Linoleic acid		$C_{18}H_{32}O_2$	252.2
8	Maleic acid	maleinic acid	$C_2H_2(CO_2H)_2$	116.
9	Malic acid (i.)	oxysuccinic or apple acid	$CO_2H \cdot CH(OH)CH_2 \cdot CO_2H$	134.1
10	" " (l.)	oxysuccinic or apple acid	$CO_2H \cdot CH(OH)CH_2 \cdot CO_2H$	134.1
11	Malonic acid	methanedicarbonic acid	$CH_2 \cdot (CO_2H)_2$	104.
12	Maltose	malt sugar	$C_{12}H_{22}O_{11} + H_2O$	360.2
13	Mandelic acid	amygdalic or phenylhydroxy-acetic acid	$C_6H_5 \cdot CH(OH) \cdot CO_2H$	152.1
14	Mannose (d.)		$C_6H_{12}O$	180.1
15	Margaric acid	heptadecoic acid	$C_{16}H_{33} \cdot CO_2H$	270.3
16	Melissic acid		$C_{29}H_{59} \cdot CO_2H$	452.5
17	Mercuric cyanide		$Hg(CN)_2$	252.1
18	fulminate		$C_2N_2HgO_2 + \frac{1}{2} : H_2O$	293.1
19	Mesaconic acid		$C_5H_6O_4$	130.1
20	Mesitylene (1:3:5)	trimethylbenzene	$(C_6H_3)(CH_3)_3$	120.1
21	Mesotartaric acid		$C_4H_6O_6 + H_2O$	168.1
22	Mesoxalic acid		$CO \cdot (CO_2H)_2 + H_2O$	136.
23	Metaldehyde		$(CH_3 \cdot CHO)n$	n.44.
24	Methane	marsh gas	CH_4	16.
25	Methyl acetate	methyl ethanoate	$CH_3CO_2 \cdot CH_3$	74.1
26	aceto-acetic ether		$CH_3 \cdot CO \cdot CH(CH_3) \cdot CO_2 \cdot C_2H_5$	144.1
27	alcohol	methyl hydrate, wood alcohol	$CH_3 \cdot OH$	32.
28	allyl ether		$CH_3OC_3H_5$	72.1
29	amine	aminomethane	$CH_3 \cdot NH_2$	31.1
30	anilin	methylphenylamine	$C_6H_5 \cdot NH \cdot CH_3$	107.1
31	benzoate		$CH_3 \cdot O_2C \cdot C_6H_5$	136.1
32	borate		$(CH_3)_3BO_3$	104.1
33	bromide	bromomethane	CH_3Br	95.
34	butadiene (2)(2,3)		$(CH_3)_2C : C : CH_2$	68.1
35	butenone (2) (1, 3)		$CH_3CO \cdot C(CH_3) : CH_2$	84.1
36	butyrate		$CH_3 \cdot O_2C \cdot C_3H_7$	102.1
37	chloride	chloromethane	CH_3Cl	50.5
38	cyanide	acetonitrile	$CH_3 \cdot CN$	41.
39	ether		$(CH_3)_2O$	46.1
40	ethyl acetone		$CH_3CO \cdot CH(CH_3) C_2H_5$	100.1

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	....	0.9166(0°)	....	90-93.	....	....	....
2	fluid	0.791(15°)	....	85.	s.	s.	s.
3	fluid	....	....	107-108.	....	....	....
4	fluid	....	....	87.	....	....	....
5	syrup	1.2403(20°)	18.	83. (1mm)	hyg.	s. a p.	s. a. p.
6	yellow	....	250-260. decomp.	....	sl. s.	s.	s.
7	yellow oil	0.9206(14°)	–18(?)	....	i.	....	....
8	rhombic prisms	1.590	130.	decomp.	s.	s.	s.
9	....	1.601	130-131.	....	s.	....	....
10	needles	1.559	100.	decomp.	deliq.	sl. s.	sl. s.
11	triclinic leaflets	....	132.	decomp.	s.	s.	....
12	needles	1.540 (17.5°)	....	....	s.	s.	....
13	rhombic	1.36(4°)	118.	decomp.	s.	s.	s.
14	rhombic	....	132.	....	v. s.	sl. s.	i.
15	crystals	....	60.	....	....	....	....
16	scales	....	91.	....	....	....	....
17	prisms	4.0026	320. decomp.	....	s.	s.	s.
18	needles	4.42	exp.	....	v. sl. s.	....	....
19	needles or prisms	....	202.	decomp.	sl. s.	....	....
20	....	0.8558(20°)	....	163.	i.	s.	s.
21	tablets	....	143.	....	s.	....	....
22	needles	....	120.	....	....	....	....
23	needles or tetra. prisms	....	subl.	....	s.	....	....
24	gas	0.559(air)	....	–160.	i.	....	....
25	....	0.9410(14°)	....	57.5	s.	s. a. p.	s. a. p.
26	....	1.009(6°)	....	186.8	....	....	....
27	fluid	0.789(0°)	–95.	66-67.	s. a. p.	s. a. p.	s. a. p.
28	....	0.77	....	46.	....	....	....
29	gas	....	....	–6.	100 : 1	s.	....
30	fluid	0.976(15°)	....	199.	....	....	....
31	fluid	1.1026	....	199.	i.	....	....
32	....	0.940	....	65.	....	....	....
33	....	1.664	....	4.5	sl. s.	s.	....
34	....	0.6940(20°)	....	40.5-41.5	....	....	....
35	oil	....	....	98-102.	....	....	....
36	fluid	1.029	....	102.	....	s.	....
37	....	0.9523	....	–23.7	sl. s.	s.	....
38	....	0.8018(4°)	–41.	82.	s.	s.	s.
39	gas	1.617(air)	....	–23.6	37: 1 vol.	s.	....
40	....	0.818(14°)	....	118.	....	....	....

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
	Methyl			
1	ethyl ether	....	$CH_3 \cdot O \cdot C_2 \cdot H_5$	60.1
2	ethyl ketone	butanone	$CH_3 \cdot CO \cdot C_2H_5$	72.1
3	fluoride	fluoromethane	CH_3F	34.
4	formate	methyl methanoate	$HCO_2 \cdot CH_3$	60.
5	iodide	iodomethane	CH_3I	142.
6	mercaptan	methyl sulphydrate	CH_3SH	48.1
7	mustard oil	thiocarbimide	CH_3NCS	73.1
8	nitrate	....	CH_3NO_3	77.0
9	nitrite	....	$CH_3 \cdot O \cdot NO$	61.0
10	oxalate	....	$(CH_3 \cdot O_2C)_2$	118.1
11	salicylate	synthetic oil of wintergreen	$C_6H_4(OCH_3) \cdot CO_2H$	152.1
12	sulphate	....	$(CH_3)SO_4$	126.1
13	sulphide	methanethio-methane	$(CH_3)_2S$	62.1
14	sulphonic acid	....	CH_3SO_3H	96.1
15	sulphuric	....	$CH_3O \cdot SO_2 \cdot OH$	112.1
16	Methylene bromide	dibromomethane	CH_2Br_2	173.9
17	chloride	dichloromethane	CH_2Cl_2	84.9
18	cyanide	....	$CH_2(CN)_2$	66.1
19	disulphonic acid	....	$CH_2(SO_3H)_2$	176.2
20	iodide	diiodomethane	CH_2I_2	268.
21	Milk sugar	lactose	$C_{12}H_{22}O_{11} + 2H_2O$	360.2
22	Morphine	....	$C_{17}H_{19}NO_3 + H_2O$	303.2
23	Mucic acid	saccharolactic acid	$(OH)_4C_4H_4(CO_2H)_2$	210.1
24	Naphthalene	tar champhor	$C_{10}H_8$	128.1
25	sulphonic acid (α)	....	$C_{10}H_7(SO_3H) + H_2O$	226.1
26	" " (β)	....	$C_{10}H_7(SO_3H) + H_2O$	226.1
27	Naphthol (α)	alphanaphthol	$C_{10}H_7 \cdot OH$	144.1
28	" (β)	betanaphthol	$C_{10}H_7 \cdot OH$	144.1
29	Naphthol sulphonic acid (α)	....	$OHC_{10}H_6SO_3H$	224.1
30	Naphthol sulphonic acid (β)	....	$OHC_{10}H_6SO_3H$	224.1
31	Naphthyl amine (α)	naphthalidene	$C_{10}H_7 \cdot NH_2$	143.1
32	" " (β)	....	$C_{10}H_7 \cdot NH_2$	143.1
33	Nicotine	betapyridyl-alpha-n-methylpyrrolidin	$C_5H_4N \cdot C_4H_7N \cdot CH_3$	162.2
34	Nicotinic acid	metapyridinecar-boxilic acid	$C_5H_4N \cdot CO_2H$	123.1
35	Nitranilin (o.)	....	$C_6H_4 \cdot NO_2 \cdot NH_2$	138.1
36	" (m.)	....	$C_6H_4 \cdot NO_2 \cdot NH_2$	138.1
37	" (p.)	....	$C_6H_4 \cdot NO_2 \cdot NH_2$	138.1
38	Nitro-benzene	oil of mirbane	$C_6H_5NO_2$	123.1
39	carbon	....	$C(NO_2)_4$	196.1

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O = 1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	....	0.7252(0°)	....	10.8	s.	s. a. p.	s. a. p.
2	fluid	0.8125(13°)	....	81.	....	....	....
3	....		....	....	s.	....	....
4	....	0.9869(11°)	....	32.3	s.	s. a. p.	s. a. p.
5	fluid	2.199	....	43.8	....	s.	....
6	fluid	....	....	6.	i.	s.	s.
7	....	....	34.	119.	....	....	....
8	fluid	1.182(20°)	....	66.expl.	....	....	....
9	gas	0.991	....	−12.	....	....	....
10	monoclinic tabl.	1.1566	51.	163.3	sl. s.	s.	....
11	fluid	1.1819(10°)	....	224.	s.	s.	s.
12	oil	1.3276(20°)	....	188.3-188.6	....	....	....
13	fluid	0.845(21°)	....	37.5	....	....	....
14	syrup	....	130. decomp.	....	....	....	....
15	oil	....	−30.	....	s.	s.	....
16	fluid	2.0844 (11.5°)	....	98. (756mm)	....	....	....
17	fluid	1.36(0°)	....	41.6	i.	....	....
18	....	....	....	109.	s.	....	....
19	needles	....	....	....	deliq.	....	....
20	yellow	3.34	4.	180.	....	....	....
21	rhombic	1.525	....	decomp.	17 : 100	sl. s.	....
22	rhombic	1.32	243.	decomp.	0.2:100h.	s.	sl. s.
23	powder	....	206. decomp.	....	sl. s.	i.	....
24	colorless need. or leaflets	1.145(4°)	79-80.	218.2	i.	s.	v. s.
25	deliquescent	....	85-90	....	v. s.	s.	sl. s.
26	leaf. not deliq.	....	....	....	....	....	....
27	monoclin. need.	1.224	94.	278-280.	sl. s. h.	s.	s.
28	leaflets	1.217	122.	285-286.	sl. s. h.	s.	s.
29	rhombic tablets	....	250.(?)	....	s.	....	....
30	leaflets	....	122.	....	v. s.	v. s.	....
31	colorless need.	....	50.	300.	0.2 : 100 c.	v. s.	v. s.
32	leaflets	....	111-112.	294.	s.	....	....
33	fluid	1.011	....	250. decomp.	s.	s.	s.
34	colorless need.	....	228-229. subl.	....	s. h.	s.	i.
35	orange-yellow need.	....	71.5	....	s. h.	s.	v. s.
36	lg. yw. rhom. need.	1.430	109.9	285.	1 : 600	....	....
37	lg. yw. need.	1.424	147.	....	sl. s.	s.	....
38	....	1.20(3°)	3.	205. (730mm)	i.	s.	s.
39	white crystals	....	13.	126.	i.	s.	s.

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Nitro-phenol (o.)...	....	$C_6H_4 \cdot NO_2 \cdot OH$......	139.1
2	" (m.)..	....	$C_6H_4 \cdot NO_2 \cdot OH$......	139.1
3	" (p.)..	....	$C_6H_4 \cdot NO_2 \cdot OH$......	139.1
4	Nitroso-anilin (p.) .	....	$C_6H_4(NO)NH_2$.......	122.1
5	benzene.........	....	$C_6H_5(NO)$..........	107.1
6	phenol (p.)......	quinon monoxime.	$C_6H_4 \cdot NO \cdot OH$.......	123.1
7	Nitro-toluene (o.)..	....	$C_6H_4 \cdot NO_2 \cdot CH_3$......	137.1
8	" (m.)..	....	$C_6H_4 \cdot NO_2 \cdot CH_3$......	137.1
9	" (p.)...	....	$C_6H_4 \cdot NO_2 \cdot CH_3$......	137.1
10	Oleic acid.........	oleinic acid.......	$C_{17}H_{33} \cdot CO_2H$........	282.3
11	Oxalic acid........	....	$CO_2H \cdot CO_2H + 2H_2O$..	126.0
12	Palmitic acid......	cetylic acid......	$C_{15}H_{31} \cdot CO_2H$........	256.3
13	Palmitin..........	tripalmitin.......	$C_3H_5(OC_{16}H_{31}O)_3$....	807.
14	Paracyanogen.....	....	$(CN)n$..............	n26.
15	Paraformaldehyde .	trioxymethylene, paraform	$(CH_2O)_2$...........	60.
16	Paraldehyde......	....	$C_6H_{12}O_3$............	132.1
17	Pentane (n.)......	amyl hydride.....	$CH_3(CH_2)_3CH_3$......	72.1
18	Phenanthrene.....	orthodiphenylene-ethylene	$(C_6H_4 \cdot CH)_2$........	178.1
19	Phenol...........	carbolic acid, phenyl hydrate	$C_6H_5 \cdot OH$..........	94.1
20	phthalein........	dihydroxyphtalo-phenone	$(C_6H_4 \cdot OH)_2C : C_6H_4CO_2$	318.1
21	sulphonic acid (o.)	sulphocarbolic (o.)	$C_6H_4 \cdot OH \cdot SO_3H$.....	174.1
22	" " (m.)	" (m.)	$C_6H_4 \cdot OH \cdot SO_3H + 2H_2O$	210.2
23	" " (p.)	" (p.)	$C_6H_4 \cdot OH \cdot SO_3H$.....	174.1
24	Phenyl cyanide....	benzonitrile......	C_6H_5CN............	103.1
25	ether............	....	$(C_6H_5)_2O$...........	170.1
26	hydrazine.......	....	$C_6H_5 \cdot NH \cdot NH_2$.....	108.1
27	isocyanide.......	....	C_6H_5NC............	103.1
28	mustard oil......	thiocarbanil......	$C_6H_5N \cdot CS$..........	135.2
29	salicylate........	salol............	$C_6H_4(OC_6H_5)CO_2H$...	214.1
30	thiourea.........	phenylthiocarba-mide	$CS(NH_2)NH \cdot C_6H_5$...	152.2
31	urea............	phenylcarbamide..	$CO(NH_2)NH \cdot C_6H_5$...	136.1
32	Phenylene-diamine (o.)	....	$C_6H_5(NH_2)_2$.........	108.1
33	Phenylene-diamine (m.)	metadiamino-benzene	$C_6H_5(NH_2)_2$.........	108.1
34	Phenylene-diamine (p.)	....	$C_6H_5(NH_2)_2$.........	108.1
35	Phenyldiamine (3) .	sulphonic acid....	$(NH_2)_2C_6H_3SO_3H + 1_3H_2O$	205.2
36	Phthalic acid (o.)..	naphthalic acid...	$C_6H_4(CO_2H)_2$........	166.1
37	aldehyde (o.)....	....	$C_6H_4(CHO)_2$.........	134.1
38	anhydride (o.)....	....	$C_6H_4(CO)_2O$.........	148.
39	Picric acid........	trinitrophenol; carbazotic or nitroxanthic acid	$C_6H_2(NO_2)_3OH$ (1:2:4:6)	229.2

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O = 1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	yw. need. or prisms	1.451(4°)	45.	214.	s.	s.	s.
2	yellow	....	96.	194.	s.	v. s.	v. s.
3	colorless need.	1.468	115.	....	sl. s.	v. s.	....
4	blue needles	....	174.	....	....	....	(s.benz.
5	tablets	....	68.	....	....	....	....
6	rhomb. green	....	decomp.	....	s.	s.	s.
7	....	1.166(24°)	-10.5	223.	i.	s.	....
8	....	1.68(22°)	16.	230-231	....	s.	....
9	rhombic	1.123(fl.)	54.	238.	....	s.	....
10	colorless need.	0.89	....	286.	....	....	....
11	monoclinic	1.63	187. (anhyd)	....	8:100 (10°)	s.	s.
12	scales	....	62.	....	i.	s. h.	s.
13	....	....	61.5	....	s. h.	sl. s.	v. s.
14	....	....	....	subl.	i.	i.	....
15	white	....	....	....	s.	....	....
16	....	0.998(15°)	10.5	124.	1:8	....	....
17	fluid	0.6263(17°)	....	37.	....	....	....
18	leaf. or tabl.	1.063(100°)	100.	340.	i.	1:50	s.
19	gray need.	1.08	42.5	181.5	6:100	sl. s. h.	s.
20	triclinic	....	250-253.	....	s. h.	v. s. h.	s.
21	....	....	....	....	v. s.	v. s.	....
22	needles	....	....	....	s.	s.	....
23	syrup	....	....	....	s.	s.	....
24	....	1.0084(17°)	-13.	190.6	1:100 (100°)	s. a. p.	s. a. p.
25	needles	....	28.	253.	i.	s.	s.
26	crystals	1.097(23°)	23.	241.	sl. s.	v. s.	v. s.
27	greenish	0.9775(15°)	....	165-166.	....	....	....
28	....	....	....	222.	i.	s.	s.
29	needles or tabl.	....	42.	....	i.	(sol. in $CHCl_3$)	....
30	needles	....	154.	....	1:400 h.	s.	....
31	monoclin. need.	....	147.	....	s. h.	s.	s.
32	tabl. or tetr. leaf.	....	102.	252.	s. h.	v. s.	v. s.
33	rhombic	....	63.	287.	sl. s.	s.	s.
34	monocl. or tabl.	....	140.	267.	s.	s.	s.
35	rhomb. tabl.	....	....	....	1:100	v. sl. s.	v. sl. s.
36	rhombic	1.585	195.	....	sl. s.	s.	s.
37	....	....	52.	....	s.	....	....
38	long needles	1.56	128.	284.	....	....	....
39	rhomb. yw. leaf.	1.74	122.	expl.	sl. s.	s.	s.

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Pinacone	tetramethylethyleneglycol	$(CH_3)_2(C\cdot OH)_2(CH_3)_2$	118.1
2	Pinene	Australene	$C_{10}H_{16}$	136.1
3	Pinol		$C_{10}H_{16}O$	152.1
4	Piperidene	hexahydropyridine	$CH_2 < {CH_2\cdot CH_2 \atop CH_2\cdot CH_2} > NH$	85.1
5	Piperonal	heliotropin	$(CH_2O_2)C_6H_3\cdot CHO$	150.1
6	Propane		C_3H_8	44.1
7	Propionic acid	methylacetic or ethylcarbonic acid	$C_2H_5\cdot CO_2H$	74.1
8	Propyl alcohol (n.)		$CH_3\cdot CH_2\cdot CH_2OH$	60.1
9	Pyridine		C_5H_5N	79.1
10	sulphonic acid (3)		$C_5H_4N\cdot SO_3H$	159.1
11	Pyrocatechin	orthodioxybenzene	$C_6H_4(OH)_2$	110.1
12	Pyrogallol (1:2:3)	pyrogallic acid	$C_6H_3(OH)C$	126.1
13	Quinic acid	chinic or kinic acid	$C_6H_7(OH)_4\cdot CO_2H$	192.1
14	Quinoline	chinoline	$C_6H_4 < {CH : CH \atop N = CH}$	129.1
15	Quinolinic acid (1 : 2 : 3)	alphabetapyridinedicarboxylic acid	$C_5H_3N(CO_2H)_2$	167.1
16	Quinone	chinone, benzoquinone	$C_6H_4O_2$	108.
17	Racemic acid	paratartaric acid	$(CO_2H\cdot CH(OH)\cdot)_2+H_2O$	168.1
18	Raffinose	mellitose	$C_{18}H_{32}O_{16}+5H_2O$	594.3
19	Resorcine	metadioxybenzene	$C_6H_4(OH)_2$	110.1
20	Rhamnite		$C_5H_6(OH)_5CH_3$	166.1
21	Rhamnose	isodulcit	$CH_3(CHOH)_4CHO+H_2O$	182.1
22	Rosanilin	triaminodiphenyltolylcarbinol	$C_{20}H_{21}N_3O$	319.3
23	Rosalic acid	aurin red	$C_{20}H_{16}O_8$	304.1
24	Saccharic acid (d.)		$C_4H_4(OH)_4(CO_2H)_2$	210.1
25	Saccharine (d.)		$C_6H_{10}O_5$	162.1
26	Saccharin	benzosulphinide	$C_6H_4 < {CO \atop SO_2} > NH$	183.1
27	Salicylic acid	ortho-oxybenzoic acid	$C_6H_4\cdot OH\cdot CO_2H$	138.1
28	Salol, see phenyl salicylate			
29	Silver fulminate		$C_2Ag_2N_2O_2$	299.9
30	Sodium ethyl		NaC_2H_5	52.1
31	glycerate		$NaC_3H_7O_3$	114.1
32	Starch		$(C_6H_{10}O_5)n$	n162.1
33	Stearic acid	cetylacetic acid	$C_{17}H_{35}\cdot CO_2H$	284.4
34	Stearine	tristearine	$C_3H_5(OC_{18}H_{35}O)_3$	891.1
35	Succinic acid	ethylenedicarboxylic acid	$CO_2H\cdot(CH_2)_2CO_2H$	118.1
36	Sugar (cane)	saccharose	$C_{12}H_{22}O_{11}$	342.2

ORGANIC COMPOUNDS (Continued)

No.	Crystal-line form and color	Sp. gr. $H_2O = 1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	small needles	0.96718 (15°)	35-38.	171-172.	s. h.	s.	....
2	....	....	....	156.	i.	s.	....
3	fluid	0.942(20°)	....	184.	....	....	....
4	fluid	0.7810 (105°)	....	106.	s.	s.	....
5	yellow crys.	....	37.	263.	s. h.	s.	....
6	gas	0.613(−25°)	....	−45.	....	s.	....
7	....	0.996(19°)	−36.	140.7	s. a. p.	s.	s.
8	fluid	0.8066(15°)	....	97.4	s.	s.	s.
9	fluid	0.986(0°)	....	116.7	s.	....	....
10	needles of leaf.	....	....	....	v. s.	v. sl. s.	i.
11	leaf. or need.	1.344	104.	240-245.	v. s.	v. s.	v. s.
12	leaf. or need.	1.463(40°)	133.	293.	44 : 100	s.	s.
13	monoclin. prisms	....	162.	decomp.	s.	i.	....
14	fluid	1.0947(20°)	....	240.	....	s.	(s. CS_2)
15	short prisms	....	231.	decomp.	sl. s.	sl. s.	v. sl. s.
16	yellow needles	1.31	116.	subl.	s. h.	s.	s.
17	triclinic	1.6873	205-206.	....	20 : 100	s.	....
18	crystals	....	118-119. anh.	....	14 : 100	sl. s.	....
19	rhomb. tabl.	1.2717(15°)	111.	276.5	v. s.	v. s.	v. s.
20	triclin. prisms	....	121.	....	v. s.	v. s.	v. sl. s.
21	monoclinic	....	92-93.	....	s.	s.	....
22	colorl. need. o. tab.	....	....	....	sl. s.	v. s.	i.
23	red leaflets	....	decomp.	decomp.	v. sl. s.	v. s. h.	s.
24	....	....	....	....	v. s.	v. s.	sl. s.
25	rhombic prisms	....	160-161.	....	s.	....	....
26	crystals	....	220.	....	s.	s.	(s. h. xylol)
27	need. or monoclin.	1.443	159.	subl.	sl. s.	s.	s.
28	....	....	....	....	....	....	....
29	small need.	....	expl.	....	2.8 100h.	(v. s. NH_3)	....
30	....	....	....	....	....	....	....
31	white powder	....	....	....	decomp.	s.	....
32	amorphous	....	....	....	i.	i.	i.
33	leaflets	0.8521 (69.5°)	69.2	....	i.	s. h.	s.
34	crystals	1.0101(15°)	71.6	....	i.	s. h.	s. h.
35	monoclinic	1.552	185.	235.	s.	s.	s.
36	monoclinic	1.588(20°)	189. decomp.	....	198:100 (12°)	sl. s.	....

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Sulphanilic acid (p.)	para-aminobenzene-sulphonic acid	$NH_2 \cdot C_6H_4 \cdot SO_3H + 2H_2O$	209.2
2	Sulphonal	sulphonemethane	$(CH_3)_2C(SO_2 \cdot C_2H_5)_2$	228.3
3	Tannin	tannic or gallotannic acid	$C_{14}H_{10}O_9$	322.1
4	Tartaric acid (i.)		$CO_2H \cdot (CH(OH))_2 CO_2H + H_2O$	168.1
5	" " (d.)	dioxysuccinic acid	$CO_2H \cdot (CH(OH))_2 CO_2H$	150.1
6	" " (l.)		$CO_2H(CH(OH))_2 CO_2H$	150.1
7	Terpenol		$C_{10}H_{18}O$	154.2
8	Terpentine		$C_{10}H_{16}$	136.1
9	Terpineol	terpilenol	$C_{10}H_{16} \cdot H_2O$	154.2
10	Tetraethyl-ammonium hydroxide		$(C_2H_5)_4NOH$	147.2
11	silicon		$(C_2H_5)_4Si$	144.6
12	Tetramethyl-ammonium hydroxide		$(CH_3)_4NOH$	91.1
13	Tetramethyl-silicon		$(CH_3)_4Si$	88.5
14	Theine, see caffeine			
15	Theobromine	dimethylxanthine	$C_7H_8N_4O_2$	180.2
16	Thio-urea		$NH_2 \cdot CS \cdot NH_2$	76.2
17	Toluene	toluol, methylbenzene	$CH_5 \cdot CH_3$	92.1
18	sulphonic acid (o.)		$CH_3 \cdot C_6H_4 \cdot SO_3H + 2H_2O$	208.2
19	sulphonic acid (m.)		$CH_3 \cdot C_6H_4 \cdot SO_3H + H_2O$	190.1
20	sulphonic acid (p.)		$CH_3 \cdot C_6H_4 \cdot SO_3H + 4H_2O$	244.2
21	Toluic acid (o.)	methylbenzoic acid	$C_6H_4 \cdot CH_3 \cdot CO_2H$	136.1
22	" " (m.)	metatoluylic acid	$C_6H_4 \cdot CH_3 \cdot CO_2H$	136.1
23	" " (p.)	paratoluylic acid	$C_6H_4 \cdot CH_3 \cdot CO_2H$	136.1
24	Toluidine (o.)	orthoaminotoluene	$CH_3 \cdot C_6H_4 \cdot NH_2$	107.1
25	" (m.)	meta-aminotoluene	$CH_3 \cdot C_6H_4 \cdot NH_2$	107.1
26	" (p.)	para-aminotoluene	$CH_3 \cdot C_6H_4 \cdot NH_2$	107.1
27	Tolyl chloride (o.)		$C_6H_4 \cdot CH_3 \cdot CH_2Cl$	140.5
28	" " (m.)		$C_6H_4 \cdot CH_3 \cdot CH_2Cl$	140.5
29	" " (p.)		$C_6H_4 \cdot CH_3 \cdot CH_2Cl$	140.5
30	Triazobenzene		$C_6H_5 \cdot N : N_2$	119.2
31	Tribrom-acetic acid		$C \cdot Br_3 \cdot CO_2H$	296.9
32	phenol	bromol	$C_6H_2 \cdot Br_3 \cdot OH$	330.9
33	Trichlor-acetic acid		$CCl_3 \cdot CO_2H$	163.4
34	benzene (s.) (1 : 3 : 5)		$C_6H_3 \cdot Cl_3$	181.4
35	benzene (as.) (1 : 2 : 4)		$C_6H_3 \cdot Cl_3$	181.4
36	benzene (v.) (1 : 2 : 3)		$C_6H_3 \cdot Cl_3$	181.4
37	ethane (1 : 1 : 1)		$CH_3 \cdot CCl_3$	133.4
38	" (1 : 2 : 2)		$CH_2Cl \cdot CH \cdot Cl_2$	133.4
39	phenol (1 : 2 : 4 : 6)		$CH_2 \cdot Cl_3 \cdot OH$	197.4
40	Triethyl amine		$(C_2H_5)_3N$	101.2
41	boride		$(C_2H_5)_3B$	98.1

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O=1$	Melting-point °C	Boiling-point °C	Solubility in Water	Alcohol	Ether
1	rhomb. or mono. tab.	....	....	....	....	....	....
2	prisms	....	125.	....	....	....	....
3	amorphous	....	decomp.	....	s.	sl. s.	v. sl. s.
4	tablets	1.666	140-143. (anh)	....	v. s.	s.	....
5	monoclinic	1.764	168-170.	....	v. s.	v. s.	i.
6	monoclinic	1.764	170.	....	v. s.	v. s.	i.
7	prisms	....	70.	....	....	....	....
8	oil	0.8587	....	158.	v. sl. s.	s. a. p.	s. a. p.
9	....	0.9357(20°)	35.	218.	i.	v. s.	v. s.
10	deliq. need.	....	190. decomp.	....	v. s.	s.	....
11	....	0.7682	....	153.	i.	....	....
12	deliq. crystals	....	decomp.	....	v. s.	....	....
13	....	....	30-31.	....	i.	....	....
14	....	....	....	....	....	....	....
15	rhombic mic.	....	290. subl.	decomp.	sl. s.	sl. s.	sl. s.
16	rhombic prisms	1.43	180.	....	s.	v. sl. s.	v. sl. s.
17	fluid	0.882(0°)	....	111.	i.	sl. s.	s.
18	crystals	....	....	....	....	....	....
19	needles	....	....	....	....	....	....
20	prisms or leaflets	....	92.	....	....	....	....
21	long needles	....	102.	....	s. h.	....	....
22	prisms	....	109-110.	263.	s.	....	....
23	need.	....	180.	275.	s. h.	v. s.	....
24	fluid	1.003(20°)	....	197.	....	....	....
25	fluid	0.998(25°)	....	197.	....	....	....
26	leaflets	1.046	45.	198.	sl. s.	....	....
27	....	....	....	197-199.	....	....	....
28	....	....	....	195-196.	....	....	....
29	....	....	....	201.	....	....	....
30	oil	1.098	....	73.5	i.	sl. s.	sl. s.
31	monoclin. tabl.	....	135.	245.	s.	s.	....
32	long needles	....	95.	subl.	v. sl. s.	v. s.	....
33	rhombic, deliq.	1.62(46°)	52.3	195-200.	v. s.	s.	s.
34	long needles	....	63.4	208.5	....	....	....
35	....	1.574(10°)	16.	213.	....	....	....
36	gray tablets	....	53-54.	218-219.	....	sl. s.	....
37	....	1.34(0°)	....	75.	....	....	....
38	....	1.422(0°)	....	115.	....	....	....
39	rhombic	....	67-68.	243-244	....	v. s.	v. s.
40	....	0.673(0°)	....	89.	v. s.	v. s.	....
41	....	0.6961(23°)	....	95.	....	s.	s.

PHYSICAL CONSTANTS OF

No.	Name	Synonyms	Formula	Mol. wt.
1	Trimethyl carbinol	....	$(CH_3)_3C\cdot OH$	74.1
2	Trinitro-benzene (s.) (1 : 3 : 5)	....	$C_6H_3(NO_2)_3$	213.2
3	naphthaline (α)	....	$C_{10}H_5\cdot(NO_2)_3$	263.2
4	" (β)	....	$C_{10}H_5\cdot(NO_2)_3$	263.2
5	" (γ)	....	$C_{10}H_5\cdot(NO_2)_3$	263.2
6	phenol (s.), see	picric acid		
7	" (1 : 3 : 4 : 6) (β)	....	$C_6H_2(NO_2)_3OH$	229.2
8	phenol (1 : 2 : 3 : 6) (γ)	....	$C_6H_2(NO_2)_3OH$	229.2
9	toluene(s.)(1:2:4:6)	....	$C_6H_2(NO_2)3\cdot CH_3$	227.2
10	Triphenyl carbinol	....	$(C_6H_5)3C\cdot OH$	260.1
11	Urea	carbamide	$CO(NH_2)_2$	60.1
12	Urethane	ethyl carbamate	$CO\cdot NH_2\cdot O\cdot C_2H_5$	89.1
13	Uric acid	....	$C_5H_4N_4O_3$	168.2
14	Valeric acid (n.)	normal propylacetic acid	$CH_3(CH_2)_3\cdot CO_2H$	102.1
15	Vanillic acid (3:4:1)	methylprotocatechuic acid	$C_6H_3(OCH_3)\cdot(OH)\cdot CO_2H$	168.1
16	Vanilline (3:4:1)	methylprotocatechuic aldehyde	$(C_6H_3(OCH_3)OH)CHO$	152.1
17	Wood alcohol, see	methyl alcohol		
18	Xanthene	....	$C_6H_4<{CH_2 \atop O}>C_6H_4$	182.1
19	Xanthine	ureous acid	$C_5H_4N_4O_2$	152.2
20	Xylene (o.)	xylol, orthodimethylbenzene	$C_6H_4(CH_3)_2$	106.1
21	" (m.)	metadimethylbenzene	$C_6H_4(CH_3)_2$	106.1
22	" (p.)	paradimethylbenzene	$C_6H_4(CH_3)_2$	106.1
23	Zinc ethyl	....	$Zn(C_2H_5)_2$	123.5
24	methyl	....	$Zn(CH_3)_2$	95.5

ORGANIC COMPOUNDS (Continued)

No.	Crystalline form and color	Sp. gr. $H_2O = 1$	Melting-point °C	Boiling-point °C	Solubility in Water	Solubility in Alcohol	Solubility in Ether
1	rhomb. tablets	0.7864	25.	82.94	deliq.	....	....
2	leaflets or tab.	....	121-122	decomp.	s. h.	s. h.	....
3	monoclinic	....	122.	....	(s. acet.)	v. s.	(s. chlo.)
4	monoclinic	....	218.	....	....	s.	sl. s.
5	yellow leaflets	....	154.	....	....	sl. s.	....
6	....	....	....	....	....	....	....
7	needles	....	96.	....	....	v. s.	v. s.
8	small needles	....	117-118.	....	....	v. s.	v. s.
9	rhombic	....	82.	....	....	s. h.	....
10	rhombohedric	....	159.	360. +	....	s.	s.
11	tetragonal	1.333	132.	decomp.	1:1	2 : 10	sl. s.
12	leaflets	0.9862(21°)	51-52.	180.	s.	....	....
13	small scales	1.855	decomp.	decomp.	v. sl. s.	i.	i.
14	....	0.9577(0°)	-58.	184-185.	1: 27	....	....
15	needles	....	207.	subl.	s. h.	s.	....
16	monoclinic need.	....	80-81.	subl.	s. h.	s.	s.
17	....	....	....	....	....	....	....
18	leaflets	....	99.	312.	i.	s.	....
19	powder	....	subl.	....	sl. s. h.	....	(s. NH_3)
20	....	0.756(14°)	-28.	142-143.	i.	v. s.	v. s.
21	....	0.878(0°)	-54.	139.8	i.	v. s.	v. s.
22	monoclinic prisms	0.862 (19.°5)	15.	138.	i.	v. s.	v. s.
23	fluid	1.182	....	118.	decomp.	decomp.	s.
24	fluid	1.386(10°)	....	46.	decomp.	....	....

PERIODIC ARRANGEMENT OF THE ELEMENTS—MENDELEJEFFS (REVISED TO 1911)

Series	Zero Group	Group I — R_2O	Group II — RO	Group III — R_2O_3	Group IV RH_4 RO_2	Group V RH_3 R_2O_5	Group VI RH_2 RO_3	Group VII RH R_2O_7	Group VIII — RO_4
0									
1		Hydrogen H = 1.008							
2	Helium He = 3.99	Lithium Li = 6.94	Glucinum (Beryllium) Gl = 9.1	Boron B = 11.0	Carbon C = 12.00	Nitrogen N = 14.01	Oxygen O = 16.00	Fluorine F = 19.0	
3	Neon Ne = 20.2	Sodium Na = 23.00	Magnesium Mg = 24.32	Aluminum Al = 27.1	Silicon Si = 28.3	Phosphorus P = 31.04	Sulphur S = 32.07	Chlorine Cl = 35.46	
4	Argon A = 39.88	Potassium K = 39.10	Calcium Ca = 40.09	Scandium Sc = 44.1	Titanium Ti = 48.1	Vanadium V = 51.06	Chromium Cr = 52.0	Manganese Mn = 54.93	Iron Fe = 55.85 Cobalt Co = 58.97 Nickel Ni = 58.68 (Cu)
5		Copper Cu = 63.57	Zinc Zn = 65.37	Gallium Ga = 69.9	Germanium Ge = 72.5	Arsenic As = 74.96	Selenium Se = 79.2	Bromine Br = 79.92	
6	Krypton Kr = 82.9	Rubidium Rb = 85.45	Strontium Sr = 87.63	Yttrium Y = 89.0	Zirconium Zr = 90.6	Columbium (Niobium) Cb = 93.5	Molybdenum Mo = 96.0		Ruthenium Ru = 101.7 Rhodium Rh = 102.9 Palladium Pd = 106.7 (Ag)
7		Silver Ag = 107.88	Cadmium Cd = 112.40	Indium In = 114.8	Tin Sn = 119.0	Antimony Sb = 120.2	Tellurium Te = 127.5	Iodine I = 126.92	
8	Xenon Xe = 130.2	Caesium Cs = 132.81	Barium Ba = 137.37	Lanthanum La = 139.0	Cerium Ce = 140.25	Praseodymium Pr = 140.6	Neodymium Nd = 144.3		
9		Samarium Sa = 150.4		Gadolinium Gd = 157.3	Terbium Tb = 159.2		Erbium Er = 167.4		
10		Thulium Tm = 168.5		Ytterbium (Neoytterbium) Yb = 172.0		Tantalum Ta = 181.0	Tungsten W = 184.0		Osmium Os = 190.9 Iridium Ir = 193.1 Platinum Pt = 195.2 (Au)
11		Gold Au = 197.2	Mercury Hg = 200.0	Thalium Tl = 204.0	Lead Pb = 207.10	Bismuth Bi = 208.0			
12			Radium Ra = 226.4		Thorium Th = 232.0		Uranium U = 238.5		

QUALITATIVE ANALYSIS SCHEME

(From A. A. Noyes' Qualitative Analysis, by permission.)

Basic Constituents

Separation of the Basic Constituents into Groups

<table>
<tr><td colspan="7">Solution in dilute nitric acid containing all the common basic constituents. Add NH_4Cl.</td></tr>
<tr><td rowspan="4">Precipitate:
Silver-Group
(Bi, Pb, Ag, Hg),
as chlorides.</td><td colspan="6">Filtrate: Saturate with H_2S gas.</td></tr>
<tr><td colspan="2">Precipitate: Copper-Group and Tin-Group as sulphides.
Treat with $(NH_4)_2S_4$.</td><td colspan="4">Filtrate: add NH_4OH and $(NH_4)_2S$.</td></tr>
<tr><td rowspan="2">Residue:
Copper-Group
(Hg, Pb, Bi, Cu, Cd),
as sulphides.</td><td rowspan="2">Solution:
(Tin-Group
As, Sb, Sn),
as ammonium sulpho-salts.</td><td colspan="2">Precipitate: Aluminum-Group and Iron-Group, as hydroxides and sulphides.
Dissolve in acid, add NaOH and H_2O_2.</td><td colspan="2">Filtrate: add $(NH_4)_2CO_3$.</td></tr>
<tr><td>Filtrate:
Aluminum-Group
(Al, Cr, Zn),
as sodium salts.</td><td>Precipitate:
Iron-Group
(Mn, Fe, Co, Ni),
as hydroxides.</td><td>Precipitate:
Alkaline-Earth Group
(Ba, Sr, Ca, Mg),
as carbonates.</td><td>Filtrate:
Alkali-Group
(NH_4, K, Na),
as nitrates.</td></tr>
</table>

Analysis of the Silver-Group

<table>
<tr><td colspan="4">Precipitate: BiOCl, $PbCl_2$, AgCl, Hg_2Cl_2. Treat with HCl.</td></tr>
<tr><td>Solution $BiCl_3$.
Evaporate, pour into water.</td><td colspan="3">Residue: $PbCl_2$, AgCl, Hg_2Cl_2. Treat with hot water.</td></tr>
<tr><td rowspan="3">Precipitate: BiOCl.</td><td>Solution: $PbCl_2$. Add H_2SO_4.</td><td colspan="2">Residue: AgCl, Hg_2Cl_2. Pour NH_4OH through the filter.</td></tr>
<tr><td rowspan="2">Precipitate: $PbSO_4$.</td><td rowspan="2">Black residue: Hg and NH_2HgCl.</td><td>Solution: $(NH_3)_2$ AgCl. Add HNO_3</td></tr>
<tr><td>White precipitate: AgCl.</td></tr>
</table>

QUALITATIVE ANALYSIS SCHEME (Continued)

Separation of the Copper and Tin Groups

<table>
<tr><td colspan="2">Hydrogen sulphide precipitate: HgS, PbS, Bi_2S_3, CuS, CdS, As_2S_3, As_2S_5, Sb_2S_3, Sb_2S_5, SnS, SnS_2. Treat with ammonium polysulphide.</td></tr>
<tr><td rowspan="2">Residue: HgS, PbS, Bi_2S_3, CuS, CdS.</td><td>Solution $(NH_4)_3 AsS_4$, $(NH_4)_3SbS_4$, $(NH_4)_2SnS_3$. Add HCl.</td></tr>
<tr><td>Precipitate: As_2S_5, Sb_2S_5, SnS_2. | Filtrate: NH_4Cl. Reject.</td></tr>
</table>

Analysis of the Copper-Group

<table>
<tr><td colspan="6">Residue from Ammonium Sulphide Treatment: HgS, PbS, Bi_2S_3, CuS, CdS. Boil with HNO_3.</td></tr>
<tr><td colspan="2" rowspan="2">Residue: HgS.
Add Br_2 solution</td><td colspan="4">Solution: Pb, Bi, Cu, Cd as nitrates. Add H_2SO_4. evaporate, add water.</td></tr>
<tr><td rowspan="3">Precipitate: $PbSO_4$. Dissolve in NH_4Ac. Add K_2CrO_4.</td><td colspan="3">Filtrate: add NH_4OH.</td></tr>
<tr><td rowspan="3">Residue: Sulphur.</td><td>Solution: $HgBr_2$. Add $SnCl_2$.</td><td>Precipitate: $Bi(OH)_3$. Add Na_2SnO_2.</td><td colspan="2">Filtrate: $Cu(NH_3)_4SO_4$, $Cd(NH_3)_4SO_4$.</td></tr>
<tr><td rowspan="2">White or gray precipitate: Hg_2Cl_2 or Hg.</td><td rowspan="2">Black Residue: Bi.</td><td>To a small part add HAc and $K_4Fe(CN)_6$.</td><td>To the remainder add KCN and H_2S.</td></tr>
<tr><td>Yellow precipitate: $PbCrO_4$.</td><td>Red precipitate: $Cu_2Fe(CN)_6$.
White precipitate: $Cd_2Fe(CN)_6$.</td><td>Yellow precipitate: CdS.
Solution $K_3Cu(CN)_4$.</td></tr>
</table>

QUALITATIVE ANALYSIS SCHEME (Continued)

Analysis of the Tin-Group

Precipitate from Ammonium Sulphide Solution: As_2S_5, Sb_2S_5, SnS_2. Heat with 10 c.c. 12 normal HCl.		
Solution: $SbCl_3$, $SnCl_4$. Dilute to 50 c.c., heat, and pass in H_2S.		Residue: As_2S_5. Dissolve in HCl and $KClO_3$.
Orange Precipitate: Sb_2S_3. Dissolve in HCl, add Sn and Pt.	Solution: $SnCl_4$. Cool, dilute, pass in H_2S.	Solution: H_3AsO_4. Add NH_4OH, NH_4Cl and $MgCl_2$.
Black deposit: Sb. Treat with NaClO.	Yellow Precipitate: SnS_2. Evaporate without filtering, add Pb, boil.	White precipitate: $MgNH_4AsO_4$. Dissolve in HCl and add H_2S.
Black deposit: Sb.	Solution: $SnCl_2$. Add $HgCl_2$.	Yellow precipitate: As_2S_5, As_2S_3 and S.
	White precipitate: Hg_2Cl_2.	

Separation of the Aluminum and Iron Groups

The Ammonium Hydroxide and Ammonium Sulphide Precipitate: $Al(OH)_3$, $Cr(OH)_3$, FeS, ZnS, MnS, CoS, NiS. Dissolve in HCl and HNO_3, add NaOH.	
Precipitate: $Fe(OH)_3$, $Mn(OH)_2$, $Co(OH)_2$, $Ni(OH)_2$. Solution: $NaAlO_2$, $NaCrO_2$, Na_2ZnO_2. Add Na_2O_2 and filter.	
Filtrate: $NaAlO_2$, Na_2CrO_4, Na_2ZnO_2.	Precipitate: $Fe(OH)_3$, $MnO(OH)_2$, $Co(OH)_3$, $Ni(OH)_2$.

QUALITATIVE ANALYSIS SCHEME (Continued)

Analysis of the Aluminum-Group

<table>
<tr><td colspan="3">Filtrate from the Sodium Hydroxide and Peroxide Treatment: Na_2ZnO_2, $NaAlO_2$, Na_2CrO_4. Acidify with HNO_3 and add NH_4OH.</td></tr>
<tr><td>Precipitate: $Al(OH)_3$.
Dissolve in HNO_3,
Add $Co(NO_3)_2$, evaporate, ignite.</td><td colspan="2">Filtrate: add HAc and $BaCl_2$.</td></tr>
<tr><td rowspan="3">Blue residue: $Co(AlO_2)_2$.</td><td>Precipitate: $BaCrO_4$.
Dissolve in HCl and H_2SO_3, evaporate.</td><td>Filtrate: Zinc salt. Pass in H_2S.</td></tr>
<tr><td rowspan="2">Green color: $CrCl_3$.</td><td>White precipitate: ZnS. Dissolve in HNO_3.
Add $Co(NO_3)_2$ and Na_2CO_3, ignite.</td></tr>
<tr><td>Green residue: $CoZnO_2$.</td></tr>
</table>

Analysis of the Iron Group

<table>
<tr><td colspan="4">Precipitate produced by sodium hydroxide and peroxide:
A. Phosphate absent: $MnO(OH)_2$, $Fe(OH)_3$, $Co(OH)_3$, $Ni(OH)_2$, $Zn(OH)_2$.
B. Phosphate present: Also $BaCO_3$, $SrCO_3$, $CaCO_3$, $MgCO_3$, $FePO_4$, $Ca_3(PO_4)_2$, etc.
Dissolve in HNO_3 and H_2O_2, evaporate, heat with HNO_3 and $KClO_3$.</td></tr>
<tr><td>Precipitate: MnO_2.
Add HNO_3 and bismuth peroxide.</td><td colspan="3">Solution: Test a portion for a phosphate with $(NH_4)_2MoO_4$.
A. Phosphate absent: add NH_4OH.
B. Phosphate present: add NH_4Ac and $FeCl_3$, dilute and boil.</td></tr>
<tr><td rowspan="2">Violet Color:
$HMnO_4$.</td><td rowspan="2">Precipitate:
A. $Fe(OH)_3$.
B. Basic ferric acetate and $FePO_4$.</td><td colspan="2">Filtrate: add NH_4OH, pass in H_2S.</td></tr>
<tr><td>Precipitate: ZnS, CoS, NiS.</td><td>Filtrate:
A. Ammonium salts. Reject.
B. Ba, Ca, Sr, Mg. Treat with Alkali-Earth group.</td></tr>
</table>

QUALITATIVE ANALYSIS SCHEME (Continued)

Separation of Zinc, Nickel and Cobalt

<table>
<tr><td colspan="3">Hydrogen sulphide precipitate: ZnS, NiS, CoS. Treat with dil. HCl.</td></tr>
<tr><td colspan="2">Solution: $ZnCl_2$, $NiCl_2$, $CoCl_2$, add $NaOH$ and Na_2O_2.</td><td rowspan="2">Residue: NiS, CoS. Dissolve in HCl and HNO_3.</td></tr>
<tr><td>Filtrate: Na_2ZnO_2.
Add HAc and H_2S.</td><td>Precipitate: $Ni(OH)_2$, $Co(OH)_3$, add HCl, evaporate.</td></tr>
<tr><td rowspan="3">White precipitate: ZnS.</td><td colspan="2">Residue: $NiCl_2$, $CoCl_2$, add HCl and ether.</td></tr>
<tr><td>Yellow residue: $NiCl_2$. Dissolve in water, add tartaric acid, $NaOH$ and H_2S.</td><td>Blue solution: $CoCl_2$, evaporate, add HAc and KNO_2.</td></tr>
<tr><td>Brown coloration: presence of nickel.</td><td>Yellow precipitate: $K_3Co(NO_2)_6$.</td></tr>
</table>

Analysis of the Alkaline-Earth Group

<table>
<tr><td colspan="5">Ammonium carbonate precipitate: $BaCO_3$, $SrCO_3$, $CaCO_3$, $MgCO_3$, $(NH_4)_2CO_3$.
Dissolve in HAc, add NH_4Ac and K_2CrO_4.</td></tr>
<tr><td colspan="2">Precipitate: $BaCrO_4$.
Dissolve in HCl, evaporate.</td><td colspan="3">Filtrate: add NH_4OH and alcohol.</td></tr>
<tr><td>Test in flame.</td><td rowspan="2">Add HAc,
NH_4Ac, and
K_2CrO_4.</td><td>Precipitate: $SrCrO_4$.
Treat with $(NH_4)_2CO_3$.</td><td colspan="2">Filtrate: Ca and Mg salts.
Add $(NH_4)_2C_2O_4$.</td></tr>
<tr><td rowspan="2">Green Color: Ba.</td><td>Residue: $SrCO_3$.
Dissolve in HAc.
Add $CaSO_4$.</td><td>Precipitate: CaC_2O_4.
Dissolve in dilute
H_2SO_4, add alcohol.</td><td>Filtrate: add NH_4OH and Na_2HPO_4.</td></tr>
<tr><td>Precipitate:
$BaCrO_4$.</td><td>Precipitate: $SrSO_4$.</td><td>Precipitate: $CaSO_4$.</td><td>Precipitate: $MgNH_4PO_4$.</td></tr>
</table>

QUALITATIVE ANALYSIS SCHEME (Continued)

Analysis of the Alkali-Group

<table>
<tr><td colspan="3">Filtrate from Ammonium Carbonate precipitate: NH_4, Na, K salts. Evaporate and ignite the residue.</td></tr>
<tr><td rowspan="4">Vapor: NH_4 salts.</td><td colspan="2">Residue: KCl, NaCl. Add $HClO_4$, evaporate, add alcohol.</td></tr>
<tr><td>Residue: $KClO_4$. Dissolve in hot water, add $Na_3Co(NO_2)_6$.</td><td>Solution: $NaClO_4$. Saturate with HCl gas.</td></tr>
<tr><td rowspan="2">Yellow precipitate: $K_2NaCO(NO_2)_6$.</td><td>Precipitate: NaCl. Dissolve in water, add $K_2H_2Sb_2O_7$.</td></tr>
<tr><td>Crystalline precipitate: $Na_2H_2Sb_2O_7$.</td></tr>
</table>

Acidic Constituents

Detection of the Readily Volatile Acidic Constituents

<table>
<tr><td colspan="4">Heat the substance with dilute H_2SO_4.
Vapors: CO_2, SO_2, H_2S, NO_2, Cl_2, Br_2, I_2, HCN. Expose to the vapors:</td></tr>
<tr><td>$Ba(OH)_2$ solution.</td><td>PbAc paper.</td><td>Starch and KI paper.</td><td>$Fe(OH)_2$ or $Fe(OH)_3$ and NaOH on paper.</td></tr>
<tr><td rowspan="2">White turbidity: $BaCO_3$ or $BaSO_3$. (Shows carbonate, sulphite or thiosulphate.)</td><td rowspan="2">Black color: PbS. (Shows sulphide.)</td><td rowspan="2">Blue color: I_2 (Shows nitrite, hypochlorite, chlorate, bromate, or iodide.)</td><td>Formation of $Na_4Fe(CN)_6$. Dip in HCl.</td></tr>
<tr><td>Blue color: $Fe_4(Fe(CN)_6)_3$. (Shows cyanide.)</td></tr>
</table>

QUALITATIVE ANALYSIS SCHEME (Continued)

Detection of the Acidic Constituents Precipitated from Acid Solutions by Barium and Silver Salts

<table>
<tr><td colspan="4">To a HNO_3 solution of the substance add $BaCl_2$.</td><td colspan="3">To a HNO_3 solution of the substance add $Cd(NO_3)_2$.</td></tr>
<tr><td rowspan="3">Precipitate: $BaSO_4$. (Shows sulphate.)</td><td colspan="3">Filtrate: add Br_2.</td><td rowspan="3">Yellow precipitate: CdS. (Shows sulphide.)</td><td colspan="2">Filtrate: add $AgNO_3$.</td></tr>
<tr><td rowspan="2">Precipitate: $BaSO_4$. (Shows sulphite.)</td><td colspan="2">Filtrate: add NH_4Ac.</td><td rowspan="2">Precipitate: $AgCl$, $AgBr$, AgI, $Ag_2(CN)_2$, $AgSCN$, (Shows halides, cyanide or thiocyanates.)</td><td>Filtrate: $AgClO_3$, $AgBrO_3$. Add H_2SO_3.</td></tr>
<tr><td>Yellow precipitate: $BaCrO_4$. (Shows chromate.)</td><td>Filtrate: add $CaCl_2$. Precipitate: CaF_2. (Shows fluoride.)</td><td>Precipitate: $AgCl$, $AgBr$. (Shows chlorate or bromate.)</td></tr>
</table>

Detection of Phosphate and the Separate Halides

<table>
<tr><td colspan="5">To portions of the HNO_3 solution of the substance.</td></tr>
<tr><td>Add $(NH_4)_2MoO_4$.</td><td>Add $FeCl_3$.</td><td colspan="3">Add NaAc, HAc, $KMnO_4$ and $CHCl_3$.</td></tr>
<tr><td rowspan="3">Yellow precipitate: $(NH_4)_3PO_4$, $12MoO_3$. (Shows phosphate.)</td><td rowspan="3">Red color: $Fe(SCN)_3$. (Shows thiocyanate.)</td><td rowspan="3">Chloroform layer, purple: I_2. (Shows iodide.)</td><td colspan="2">Water layer: add H_2SO_4, more $KMnO_4$ and $CHCl_3$.</td></tr>
<tr><td rowspan="2">Chloroform layer, orange: Br_2. (Shows bromide.)</td><td>Water layer: Boil out the Br_2, add HNO_3 and $AgNO_3$.</td></tr>
<tr><td>Precipitate: $AgCl$. (Shows chloride.)</td></tr>
</table>

FLAME AND BEAD TESTS

Flame Colorations

VIOLET.

Potassium compounds. Purple red through blue glass. Easily obscured by sodium flame. Bluish green through green glass. Rubidium and Caesium compounds impart same flame as potassium compounds.

BLUES.

Azure. — Copper chloride. Copper bromide gives azure blue followed by green. Other copper compounds give same coloration when moistened with hydrochloric acid.

Light Blue. — Lead, Arsenic, Selenium.

GREENS.

Emerald. — Copper compounds except the halides, and when not moistened with hydrochloric acid.

Pure Green. — Compounds of thallium and tellurium.

Yellowish. — Barium compounds. Some molybdenum compounds. Borates, especially when treated with sulphuric acid or when burned with alcohol.

Bluish. — Phosphates with sulphuric acid.

Feeble. — Antimony compounds. Ammonium compounds.

Whitish. — Zinc.

REDS.

Carmine. — Lithium compounds. Violet through blue glass. Invisible through green glass. Masked by barium flame.

Scarlet. — Strontium compounds. Violet through blue glass. Yellowish through green glass. Masked by barium flame.

Yellowish. — Calcium compounds. Greenish through blue glass. Green through green glass. Masked by barium flame.

YELLOWS.

Yellow. All sodium compounds. Invisible with blue glass.

OXIDES WHICH IMPART DECIDED COLORS TO THE BEADS

Borax Beads

Oxides of	Oxidizing Flame	Reducing Flame
Chromium	Green	Green
Cobalt	Blue	Blue
Copper	Greenish blue	Red-opaque
Iron	Yellow	Green
Manganese	Violet	Colorless
Molybdenum	Colorless	Brown
Nickel	Brown	Gray-opaque
Titanium	Colorless	Yellow
Tungsten	Colorless	Brown
Uranium	Red	Green
Vanadium	Colorless	Green

FLAME AND BEAD TESTS (Continued)

Salt of Phosphorus Beads

Oxides of	Oxidizing Flame	Reducing Flame
Chromium	Green	Green
Cobalt	Blue	Blue
Copper	Blue	Red-opaque
Iron	Brown	Colorless
Manganese	Violet	Colorless
Molybdenum	Colorless	Green
Nickel	Yellow	Yellow
Titanium	Colorless	Violet
Tungsten	Colorless	Blue
Uranium	Green	Green
Vanadium	Yellow	Green

PREPARATION AND PROPER CONCENTRATION OF LABORATORY REAGENTS FOR GENERAL USE

Dilute Acids. Sulphuric acid. One volume strong acid to 6 volumes water.

Nitric Acid. One volume strong acid to 2 volumes water.

Hydrochloric acid. Five volumes strong acid to 8 volumes water.

Acetic acid. One volume strong acid to $2\frac{1}{2}$ volumes water.

Dilute Bases. Potassium hydroxide. 280 grams per liter of solution with water.

Sodium hydroxide. 200 grams per liter of solution with water.

Ammonium hydroxide. One volume strong ammonia (sp. gr. 90) to 2 volumes water.

Other Reagents. Ammonium sulphide. 600 cc. ammonium hydroxide is saturated with hydrogen sulphide. Dilute to one liter with ammonium hydroxide.

Sodium sulphide. Dissolve 200 grams sodium hydroxide in 800 cc. water. Saturate 400 cc. of this solution with hydrogen sulphide. Add the remaining 400 cc. of sodium hydroxide and dilute the whole to one liter.

Ammonium chloride. 267.5 grams per liter of solution with water.

Ammonium carbonate. 200 grams solid salt dissolved in 350 cc. ammonium hydroxide and dilute with water to 1 liter.

Ammonium acetate. Dilute 300 cc. strong acetic acid with 300 cc. water and neutralize with strong ammonia. Dilute to 1 liter.

Sodium acetate, 136.14 grams per liter with water.

Sodium phosphate, 119.45 grams per liter with water.

Calcium chloride, 109.51 grams per liter with water.

Magnesium sulphate, 123.28 grams per liter with water.

Barium chloride, 122.17 grams per liter with water.

Ferric chloride, 54.11 grams per liter with water and add sufficient HCl to keep in solution.

Potassium ferrocyanide, 105.72 grams per liter with water.

Lead acetate, 189.51 grams per liter with water.

Stannous chloride, 112.72 grams of the solid salt plus 200 cc. 5N HCl diluted to 1 liter with water. Add metallic tin to the solution in the bottle to keep it from oxidizing.

Mercurous nitrate, 262.34 grams per liter with water. Add sufficient nitric acid to keep solution clear and put metallic mercury in the bottle to prevent oxidation.

Cobalt nitrate, 145 grams per liter with water.

Ammonium oxalate, 35.5 grams per liter with water.

Mercuric chloride, 67.8 grams per liter with water.

Zinc sulphate, 71.9 grams per liter with water.

Manganese sulphate, 55.78 grams per liter with water.
Nickel sulphate, 70.22 grams per liter with water.
Cadmium sulphate, 64.05 grams per liter with water.
Copper sulphate, 62.4 grams per liter with water.

Miscellaneous Reagents. Aqua regia, mix 1 part HNO_3 with three parts of concentrated HCl.

Silver nitrate N/10, 17 grams per liter with water.

Magnesia mixture, dissolve 68 grams crystallized $MgCl_2$ and 165 grams NH_4Cl in 300 cc. water. Add 300 cc. dilute ammonium hydroxide and dilute to 1 liter.

Molybdate solution, dissolve 60 grams molybdic oxide (MoO_3) in 440 cc. of water and 60 cc. strong ammonia (sp. gr. 90). Pour into 500 cc. of cold nitric acid which has been diluted 250 cc. concentrated acid to 250 cc. water. Let stand in a warm place several days. Decant or filter before using.

Phenolsulphonic acid, dissolve 150 grams of phenol in 600 grams of concentrated sulphuric acid.

Yellow ammonium sulphide, 50 to 75 grams of sulphur to a liter of colorless ammonium sulphide.

Ferrous sulphate, dissolve 200 grams $FeSO_4.7H_2O$ in a liter of water. Place scraps of iron in the solution and add a few drops of H_2SO_4 from time to time.

DECI-NORMAL SOLUTIONS OF SALTS AND OTHER REAGENTS

(From the "Chemiker Kalender," published by Julius Springer, Berlin.)

Name.	Formula.	At. or mol. wt.	Hydrogen equivalent.	One H equiv. in gms.
Acetic acid	$C_2H_4O_2$	60.04	$C_2H_4O_2$	6.004
Ammonia	NH_3	17.07	NH_3	1.707
Ammonium	NH_4	18.07	NH_4	1.807
Ammonium chloride	NH_4Cl	53.53	NH_4Cl	5.353
Ammonium sulphate	$(NH_4)_2SO_4$	132.22	$\frac{1}{2}(NH_4)_2SO_4$	6.611
Ammonium sulphocyanate	$NH_4.CNS$	76.18	NH_4CNS	7.618
Barium	Ba	137.4	$\frac{1}{2}Ba$	6.87
Barium carbonate	$BaCO_3$	197.4	$\frac{1}{2}BaCO_3$	9.87
Barium chloride	$BaCl_2 + 2H_2O$	244.34	$\frac{1}{2}BaCl_2 + 2H_2O$	12.217
Barium hydroxide	$Ba(OH)_2$	171.42	$\frac{1}{2}Ba(OH)_2$	8.571
Barium oxide	BaO	153.4	$\frac{1}{2}BaO$	7.67
Bromine	Br	79.96	Br	7.996
Calcium	Ca	40.	$\frac{1}{2}Ca$	2.00
Calcium carbonate	$CaCO_3$	100.	$\frac{1}{2}CaCO_3$	5.0
Calcium chloride	$CaCl_2$	110.9	$\frac{1}{2}CaCl_2$	5.545
Calcium chloride	$CaCl_2 + 6H_2O$	219.02	$\frac{1}{2}CaCl_2 + 6H_2O$	10.951
Calcium hydroxide	$Ca(OH)_2$	74.	$\frac{1}{2}Ca(OH)_2$	3.7
Calcium oxide	CaO	56.	$\frac{1}{2}CaO$	2.8
Chlorine	Cl	35.45	Cl	3.545
Citric acid	$C_6H_8O_7.H_2O$	210.1	$\frac{1}{3}C_6H_8O_7.H_2O$	7.003
Cobalt	Co	59.	$\frac{1}{2}Co$	2.95
Copper	Cu	63.6	$\frac{1}{2}Cu$	3.18
Copper oxide	CuO	79.6	$\frac{1}{2}CuO$	3.98
Copper sulphate	$CuSO_4.5H_2O$	249.76	$\frac{1}{2}CuSO_4.5H_2O$	12.488
Cyanogen	CN	26.04	CN	2.604
Hydrochloric acid	HCl	36.46	HCl	3.646
Hydrocyanic acid	HCN	27.04	HCN	2.704

DECI-NORMAL SOLUTIONS OF SALTS AND OTHER REAGENTS
(Continued)

Name.	Formula.	At. or mol. wt.	Hydrogen equivalent.	One H equiv. in gms.
Iodine	I	126.85	I	12.685
Lactic acid	$C_3H_6O_3$	90.06	$C_3H_6O_3$	9.006
Malic acid	$C_4H_6O_5$	134.06	$\frac{1}{2}C_4H_6O_5$	6.703
Magnesium	Mg	24.36	$\frac{1}{2}Mg$	1.218
Magnesium carbonate	$MgCO_3$	84.36	$\frac{1}{2}MgCO_3$	4.218
Magnesium chloride	$MgCl_2$	93.26	$\frac{1}{2}MgCl_2$	4.663
Magnesium chloride	$MgCl_2 + 6H_2O$	203.38	$\frac{1}{2}(MgCl_2 + 6H_2O)$	10.169
Magnesium oxide	MgO	40.36	$\frac{1}{2}MgO$	2.018
Manganese	Mn	55.	$\frac{1}{2}Mn$	2.75
Manganese sulphate	$MnSO_4$	151.06	$\frac{1}{2}MnSO_4$	7.553
Mercuric chloride	$HgCl_2$	271.2	$\frac{1}{2}HgCl_2$	13.56
Nickel	Ni	58.7	$\frac{1}{2}Ni$	2.935
Nitric acid	HNO_3	63.05	HNO_3	6.305
Nitrogen	N	14.04	N	1.404
Nitrogen pentoxide	N_2O_5	108.8	$\frac{1}{2}N_2O_5$	5.204
Oxalic acid	$H_2C_2O_4$	90.02	$\frac{1}{2}H_2C_2O_4$	4.501
Oxalic acid	$C_2H_2O_4.2H_2O$	126.06	$\frac{1}{2}C_2H_2O_4.2H_2O$	6.305
Oxalic anhydride	C_2O_3	72.01	$\frac{1}{2}C_2O_3$	3.60
Phosphoric acid	H_3PO_4	98.03	$\frac{1}{3}H_3PO_4$	3.268
Potassium	K	39.15	K	3.915
Potassium bicarbonate	$KHCO_3$	100.15	$KHCO_3$	10.015
Potassium carbonate	K_2CO_3	138.3	$\frac{1}{2}K_2CO_3$	6.915
Potassium chloride	KCl	74.6	KCl	7.46
Potassium cyanide	KCN	65.19	KCN	6.519
Potassium hydroxide	KHO	56.16	KHO	5.616
Potassium oxide	K_2O	94.3	$\frac{1}{2}K_2O$	4.715
Potassium permanganate for Co_2 estimation	$KMnO_4$	158.15	$\frac{1}{6}KMnO_4$	2.636
Potassium permanganate for Mn estimation	$KMnO_4$	158.15	$\frac{1}{3}KMnO_4$	5.272
Potassium tartrate	$K_2H_4C_4O_6$	226.34	$\frac{1}{2}K_2H_4C_4O_6$	11.317
Silver	Ag	107.93	Ag	10.793
Silver nitrate	$AgNO_3$	169.97	$AgNO_3$	16.997
Sodium	Na	23.05	Na	2.305
Sodium bicarbonate	$NaHCO_3$	84.06	$NaHCO_3$	4.203
Sodium carbonate	Na_2CO_3	106.1	$\frac{1}{2}Na_2CO_3$	5.305
Sodium chloride	$NaCl$	58.5	$NaCl$	5.85
Sodium hydroxide	$NaHO$	40.06	$NaHO$	4.006
Sodium oxide	Na_2O	62.1	$\frac{1}{2}Na_2O$	3.105
Sodium sulphide	Na_2S	78.16	$\frac{1}{2}Na_2S$	3.908
Sulphuric acid	H_2SO_4	98.08	$\frac{1}{2}H_2SO_4$	4.904
Sulphur trioxide	SO_3	80.06	$\frac{1}{2}SO_3$	4.003
Tartaric acid	$C_4H_6O_6$	150.66	$\frac{1}{2}C_4H_6O_6$	7.503
Zinc	Zn	65.4	$\frac{1}{2}Zn$	3.27
Zinc sulphate	$ZnSO_4.7H_2O$	287.6	$\frac{1}{2}ZnSO_4.7H_2O$	14.38

DECI-NORMAL SOLUTIONS OF OXIDATION AND REDUCTION REAGENTS

(From the "Chemiker Kalender," published by Julius Springer, Berlin.)

Name.	Formula.	At. or mol. wt.	Hydrogen equivalent.	One H equiv. in gms.
Antimony	Sb	120.	$\frac{1}{2}$Sb	6.0
Arsenic	As	75.	$\frac{1}{2}$As	3.75
Arsenic trisulphide	As_2S_3	246.18	$\frac{1}{4}As_2S_3$	6.1545
Arsenous oxide	As_2O_3	198.	$\frac{1}{4}As_2O_3$	4.95
Barium peroxide	BaO_2	169.4	$\frac{1}{2}BaO_2$	8.47
Barium peroxide, hydrated	BaO_2+8H_2O	313.56	$\frac{1}{2}BaO_2+8H_2O$	15.678
Calcium	Ca	40.	$\frac{1}{2}$Ca	20.
Calcium carbonate	$CaCO_3$	100.	$\frac{1}{2}CaCO_3$	5.0
Calcium hypochlorite	$Ca(ClO)_2$	126.9	$\frac{1}{2}Ca(ClO)_2$	6.345
Calcium oxide	CaO	56.	$\frac{1}{2}$CaO	2.8
Chlorine	Cl	35.45	Cl	3.545
Chromium trioxide	CrO_3	100.1	$\frac{1}{3}CrO_3$	3.37
Ferrous ammonium sulphate	$FeSO_4(NH_4)_2SO_4+6H_2O$	392.4	$FeSO_4(NH_4)_2SO_4+6H_2O$	39.24
Hydroferrocyanic acid	$H_4Fe(CN)_6$	216.28	$H_4Fe(CN)_6$	21.628
Hydrogen peroxide	H_2O_2	34.02	$\frac{1}{2}H_2O_2$	1.701
Hydrogen sulphide	H_2S	34.08	$\frac{1}{2}H_2S$	1.704
Iodine	I	126.85	I	12.685
Iron	Fe	56.	Fe	5.6
Iron oxide, ferrous	FeO	72.	FeO	7.2
Iron oxide, ferric	Fe_2O_3	160.	$\frac{1}{2}Fe_2O_3$	8.0
Lead peroxide	PbO_2	238.9	$\frac{1}{2}PbO_2$	11.945
Manganese peroxide	MnO_2	87.	$\frac{1}{2}MnO_2$	4.35
Nitric acid	HNO_3	63.05	$\frac{1}{3}HNO_3$	2.102
Nitrogen trioxide	N_2O_3	76.08	$\frac{1}{4}N_2O_3$	1.902
Nitrogen pentoxide	N_2O_5	108.08	$\frac{1}{6}N_2O_5$	1.801
Oxalic acid	$C_2H_2O_4$	90.02	$\frac{1}{2}H_2C_2O_4$	4.501
Oxalic acid	$C_2H_2O_4.2H_2O$	126.06	$\frac{1}{2}C_2H_2O_4.2H_2O$	6.303
Oxygen	O	16.	$\frac{1}{2}$O	0.8
Potassium bichromate	$K_2Cr_2O_7$	294.5	$\frac{1}{6}K_2Cr_2O_7$	4.908
Potassium chlorate	$KClO_3$	122.6	$KClO_3$	12.26
Potassium chromate	K_2CrO_4	194.4	$\frac{1}{2}K_2CrO_4$	9.72
Potassium ferrocyanide	$K_4Fe(CN)_6$	368.84	$K_4Fe(CN)_6$	36.884
Potassium ferrocyanide	$K_4Fe(CN)_6+3H_2O$	422.9	$K_4Fe(CN)_6+3H_2O$	42.29
Potassium iodide	KI	166.	KI	16.6
Potassium nitrate	KNO_3	101.19	$\frac{1}{3}KNO_3$	3.373
Potassium perchlorate	$KClO_4$	138.6	$KClO_4$	13.86
Potassium permanganate	$KMnO_4$	158.15	$\frac{1}{5}KMnO_4$	3.163
Sodium chlorate	$NaClO_3$	106.5	$NaClO_3$	10.65
Sodium nitrate	$NaNO_3$	85.9	$\frac{1}{3}NaNO_3$	2.836
Sodium phosphate, sec.	$Na_2HPO_4+12H_2O$	358.35	$\frac{1}{2}Na_2HPO_4+12H_2O$	11.945
Sodium thiosulphate	$Na_2S_2O_3+5H_2O$	248.32	$NaS_2O_3+5H_2O$	24.832
Stannous chloride	$SnCl_2$	189.4	$\frac{1}{2}SnCl_2$	9.47
Stannous oxide	SnO	134.5	$\frac{1}{2}$SnO	6.425
Sulphur dioxide	SO_2	64.06	$\frac{1}{2}SO_2$	3.203
Tin	Sn	118.5	$\frac{1}{2}$Sn	5.925

SOLUBILITY CHART

	Acetate.	Arsenate.	Arsenite.	Borate.	Bromide.	Carbonate.	Chlorate.	Chloride.	Chromate.	Cyanide.	Ferricyanide.	Ferrocyanide.	Fluoride.	Hydroxide.	Iodide.	Nitrate.	Oxalate.	Oxide.	Phosphate.	Silicate.	Sulphate.	Sulphide.	Tartrate.
Al.....	W	a	..	A	W	..	W	W	..	..	..	w	I	A	W	W	A	A	A	a	W	A	W
NH_4....	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	..	W	..	W	W	W
Sb.....	..	a	A	..	w	..	..	w	A	..	..	..	W	..	w	..	A	A	w	..	w	A	A
Ba.....	W	A	A	A	W	A	W	W	A	w	w	w	a	W	W	W	A	W	A	A	I	W	A
Bi.....	W	A	..	A	w	A	W	w	A	w	..	w	A	A	A	W	A	A	A	..	W	A	A
Cd....	W	A	..	w	W	A	W	W	A	A	A	..	w	A	W	W	A	A	A	A	W	A	w
Ca.....	W	A	A	w	W	A	W	W	w	W	W	W	a	w	W	W	A	w	A	A	A	W	A
Cr.....	W	A	..	A	W	..	W	W	A	A	..	..	W	A	W	W	w	A	A	A	W	A	W
Co.....	W	A	A	A	W	A	W	W	A	a	I	I	w	A	W	W	A	A	A	A	W	A	W
Cu....	W	A	A	W	W	A	W	W	W	A	I	I	A	A	W	W	A	A	A	A	W	A	W
Au....	..	..	..	..	W	..	..	W	..	A	..	..	..	A	A	..	..	A	..	..	..	A	..
H.....	W	W	..	W	W	..	W	W	..	W	W	W	W	W	W	W	W	W	W	W	W	w	W
Fe″....	W	A	A	A	W	A	W	W	..	a	I	I	w	A	W	W	A	A	A	A	W	A	w
Fe‴...	W	A	A	A	W	..	W	W	W	..	W	I	W	A	W	W	A	A	A	A	W	A	W
Pb.....	W	A	A	A	a	A	W	a	a	A	w	A	A	A	w	W	A	A	A	A	a	A	A
Mg....	W	A	A	w	W	A	W	W	W	W	W	W	a	A	W	W	A	A	A	A	W	A	W
Mn....	W	A	A	A	W	A	W	W	W	W	I	A	A	A	W	W	w	A	A	A	W	A	w
Hg′....	w	A	A	..	a	A	W	a	A	A	..	..	W	..	A	W	A	A	A	..	w	A	w
Hg″...	W	A	A	..	W	A	W	W	w	A	A	A	w	..	A	W	A	A	A	..	W	A	A
Ni.....	W	A	A	A	W	A	W	W	A	a	I	I	w	A	W	W	A	A	A	A	W	A	A
K.....	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Ag.....	w	A	A	A	I	A	W	I	A	I	I	I	W	..	I	W	A	A	A	..	w	A	A
Na....	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Sn⁗...	W	A	..	..	W	..	..	W	..	..	..	I	W	A	W	w	W	A	A	..	W	A	..
Sn″....	W	A	A	A	W	..	W	W	A	..	..	I	W	A	W	..	A	A	A	..	W	A	A
Sr.....	W	A	A	A	W	A	W	W	w	A	W	W	a	A	W	W	A	w	A	A	a	W	A
Zn.....	W	A	A	A	W	A	W	W	W	A	A	I	w	A	W	W	A	A	A	A	W	A	A

W Soluble in water.
A Insoluble in water but soluble in acids.
w Sparingly soluble in water but soluble in acids.
a Insoluble in water and only sparingly soluble in acids.
I Insoluble in both water and acids.

SOLUBILITIES

In Grams per 100g of Water

Temperature, Deg. C.	0	10	20	30	40	50	60	70	80	90	100
Boric acid, H_3BO_3.....	1	2.5	4	5.5	7	9	11	13	17.5	22	27.5
Mercuric chlor., $HgCl_2$.	4.5	5	6.5	8	10	12	14	17.5	24.5	37.5	54
Potass. sulphate, K_2SO_4	7.5	10	11	13	15	16	17.5	19.5	21	22.5	24.5
Potass. chlorate, $KClO_3$	3.5	5	7.5	10.5	14.5	19.5	25.5	32.5	40	47.5	55.5
Potass. nitrate, KNO_3.	13.5	17	25.5	44	63	86	110	140	167		
Sodium chloride, NaCl.	34.5	35.9	36.3	36.7	37.1	37.5	37.9	38.3	38.7	39.1	39.5
Potass. chloride, KCl..	28.5	31.3	34	36.8	39.6	42.4	45.2	48	50.7	53.5	56.3
Bar. chlor., $BaCl_2.2H_2O$	32.5	33	35	37.5	41	44	47	50	53	57	63
Ammon. chlor., NH_4Cl.	29.5	32.5	37	41.5	45.5	50.3	55	60	65.8	72	77.2
Lead nitrate, $Pb(NO_3)_2$	37	44.7	52.5	61	70	78	88	97.5	106.5	116.5	127
Potass. bromide, KBr.	54.5	60	65	70.5	76	81.7	85.8	90.7	95.5	100.3	105
Sodium nitrate, $NaNO_3$	72.6	80	87.8	96	105	114.8	125	135.8	149.5	162.5	181
Aluminum sulphate, $Al_2(SO_4)_3.18H_2O$..	87	92	105	127.5	150	197					
Potassium iodide, KI..	128	136	144	152	160	167	175	184	191	199	
Silver nitrate, $AgNO_3$..	115	177.5									

INDICATORS

R. T. Thomson's table, showing the hydrogen atoms replaced by NaOH or KOH when a compound neutral to the indicator is formed. The blank spaces indicate that the end-reaction is obscure.

(From Cohn's Indicators and Test-papers, John Wiley and Sons, publishers, by permission.)

Acid	Formula	Methyl-orange	Phenolphthalein		Litmus	
		Cold	Cold	Boiling	Cold	Boiling
Sulphuric.......	H_2SO_4	2	2	2	2	2
Hydrochloric....	HCl	1	1	1	1	1
Nitric..........	HNO_3	1	1	1	1	1
Thiosulphuric...	$H_2S_2O_3$	2	2	2	2	2
Carbonic........	H_2CO_3	0	1 dilute	0	..	0
Sulphurous......	H_2SO_3	1	2	..	..	..
Hydrosulphuric..	H_2S	0	1 dilute	0	..	0
Phosphoric......	H_3PO_4	1	2	..	..	..
Arsenic.........	H_3AsO_4	1	2	..	..	..
Arsenous........	H_3AsO_3	4	..	..	0	0
Nitrous.........	HNO_2	indicator destroyed	1	..	1	..
Silicic	H_4SiO_4	0	..	..	0	0
Boric...........	H_3BO_3	0	..	..	..	..
Chromic.........	H_2CrO_4	1	2	2	..	..
Oxalic..........	$H_2C_2O_4$	..	2	2	2	2
Acetic..........	$HC_2H_3O_2$	..	1	.. 1	nearly	..
Butyric.........	$HC_4H_7O_2$	..	1	.. 1	nearly	..
Succinic........	$H_2C_4H_4O_4$	..	2	.. 2	nearly	..
Lactic..........	$HC_3H_5O_3$	..	1	..	1	..
Tartaric........	$H_2C_4H_4O_6$	..	2	..	2	..
Citric..........	$H_3C_6H_5O_7$	..	3	..	..	..

TABLE OF INDICATORS

Water has a concentration of H^+ ion of 10^{-7} and of OH^- ion of 10^{-7} moles per liter. Due to hydrolysis the composition of a titrated weak acid solution is basic and of a titrated weak base, acid. A truly neutral titrated solution of a strong acid or base has the same concentration of H^+ and OH^- as water.

Indicator	Color		OH^- concentration at change	H^+ concentration at change	For titration of
	Alkaline	Acid			
Benzopurpurin...	Red	Yellow	1	10^{-14}	Very weak acids
Trinitrobenzene..	Orange	Colorless	10^{-1}	10^{-13}	Very weak acids
Thymolphthalein.	Blue	Colorless	10^{-4}	10^{-10}	Weak acids
Phenolphthalein*.	Red	Colorless	10^{-5}	10^{-9}	Weak acids
Cochineal.......	Lilac	Yellow	10^{-8}	10^{-6}	Strong acids or bases
Litmus.........	Violet	Red	10^{-7}	10^{-7}	Strong acids or bases
Congo red.......	Orange	Violet	10^{-8}	10^{-6}	Strong acids or bases
Methyl red......	Yellow	Pink	10^{-8}	10^{-6}	Strong acids or bases
Rosolic acid.....	Red	Yellow	10^{-7}	10^{-7}	Strong acids or bases
Alizarin.........	Red	Greenish yellow	10^{-9}	10^{-5}	Weak bases
Methyl orange**.	Yellow	Pink	10^{-9}	10^{-5}	Ammonia and weak bases

* May be used in the presence of weak bases. ** May be used in the presence of carbon dioxide or hydrogen sulphide.

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS

To facilitate the use of the table the group of substances weighed given under each element as well as the substances sought under each substance weighed are arranged in the alphabetical order of their formulæ.

Weighed	Sought	Factor	Logarithm
Aluminum: Al = 27.1			−10
Al	Al_2O_3	1.8856	10.27545
	$AlPO_4$	4.5070	10.65389
$AlCl_3$	Al_2O_3	0.38282	9.58300
Al_2O_3	Al	0.53033	9.72455
	$AlCl_3$	2.6122	10.41700
	$AlPO_4$	2.3897	10.37834
	$Al_2(SO_4)_3$	3.3501	10.52506
	$Al_2(SO_4)_3 \cdot 18H_2O$	6.5232	10.81446
	$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$	9.2860	10.96791
	$(NH_4)_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$	8.8739	10.94811
$AlPO_4$	Al	0.22193	9.34621
	Al_2O_3	0.41841	9.62166
	P_2O_5	0.58175	9.76474
$Al_2(SO_4)_3$	Al_2O_3	0.29850	9.47494
$Al_2(SO_4)_3 \cdot 18H_2O$	Al_2O_3	0.15330	9.18554
$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$	Al_2O_3	0.10769	9.03218
$(NH_4)_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$	Al_2O_3	0.11269	9.05186
P_2O_5	$AlPO_4$	1.7190	10.23526
Ammonium: NH_4 = 18.04			
Ag	NH_4Br	0.90813	9.95815
	NH_4Cl	0.49592	9.69541
	NH_4I	1.3440	10.12841
$AgBr$	NH_4Br	0.52166	9.71739
$AgCl$	NH_4Cl	0.37323	9.57198
AgI	NH_4I	0.61752	9.79065
$BaSO_4$	$(NH_4)_2SO_4$	0.56608	9.75288
Br	NH_4Br	1.2258	10.08843
Cl	NH_4	0.50874	9.70650
	NH_4Cl	1.5087	10.17861
HCl	NH_4Cl	1.4669	10.16641
I	NH_4I	1.1425	10.05782
$MgNH_4PO_4 \cdot 6H_2O$	NH_3	0.06936	8.84116
	NH_4	0.07347	8.86619
	$(NH_4)_2O$	0.10607	9.02559
N	NH_3	1.2153	10.08477
	NH_4	1.2877	10.10980
	NH_4Cl	3.8187	10.58191
Ammonium:			−10
N	NH_4NO_3	5.7138	10.75693
	$(NH_4)_2O$	1.8587	10.26920
	$(NH_4)_2SO_4$	4.7161	10.67358
NH_3	$MgNH_4PO_4 \cdot 6H_2O$	14.4160	11.15884
	N	0.82268	9.91523
	NH_4Cl	3.1415	10.49714
	$(NH_4)_2CO_3$	2.8207	10.45036
	NH_4HCO_3	4.6413	10.66664
	NH_4NO_3	4.6994	10.67204
	$(NH_4)_2O$	1.5288	10.18435
	NH_4OH	2.0577	10.31338
	$(NH_4)_2PtCl_6$	13.0372	11.11518
	$(NH_4)_2SO_4$	3.8787	10.58868
	N_2O_5	3.1714	10.50126
	Pt	5.7311	10.75824
	SO_3	2.35020	10.37110
NH_4	Cl	1.9656	10.29350
	$MgNH_4PO_4 \cdot 6H_2O$	13.6085	11.13381
	N	0.77660	9.89020
	NH_4Cl	2.96560	10.47211
	$(NH_4)_2PtCl_6$	12.3068	11.09015
	Pt	5.4101	10.73321
NH_4Br	Ag	1.1011	10.04185
	$AgBr$	1.9169	10.28261
	Br	0.81577	9.91157
NH_4Cl	Ag	2.0164	10.30459
	$AgCl$	2.6793	10.42802
	Cl	0.66281	9.82139
	HCl	0.68169	9.83359
	N	0.26187	9.41809
	NH_3	0.31831	9.50286
	NH_4	0.33720	9.52789
	$(NH_4)_2O$	0.48673	9.68729
	NH_4OH	0.65516	9.81634
	$(NH_4)_2PtCl_6$	4.14995	10.61804
	Pt	1.8243	10.26110
$(NH_4)_2CO_3$	NH_3	0.35460	10.54974
NH_4HCO_3	NH_3	0.21543	9.33331
NH_4I	Ag	0.74403	9.87159
	AgI	1.6194	10.20935
	I	0.87535	9.94218
NH_4NO_3	NH_3	0.21274	9.32785
	$(NH_4)_2PtCl_6$	2.7735	10.44303
	N_2O_5	0.67470	9.82911
	Pt	1.2193	10.08609
$(NH_4)_2O$	$MgNH_4PO_4 \cdot 6H_2O$	9.4279	10.97441
	N	0.53802	9.73080
	NH_3	0.65418	9.81570
	NH_4Cl	2.0545	10.31271

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS
(Continued)

Weighed	Sought	Factor	Logarithm
Ammonium:			−10
$(NH_4)_2O$	$(NH_4)_2PtCl_6$	8.5260	10.93075
	N_2O_5	2.0741	10.31683
	Pt	3.7489	10.57381
NH_4OH	N	0.39971	9.60175
	NH_3	0.48599	9.68663
	NH_4	0.51475	9.71160
	NH_4Cl	1.5264	10.18366
	$(NH_4)_2PtCl_6$	6.3343	10.80170
	Pt	2.7846	10.44476
$(NH_4)_2PtCl_6$	NH_3	0.07670	8.88482
	NH_4	0.08126	8.90985
	NH_4Cl	0.24097	9.38196
	NH_4NO_3	0.36054	9.55697
	$(NH_4)_2O$	0.11721	9.06925
	NH_4OH	0.15787	9.19830
	$(NH_4)_2SO_4$	0.29759	9.47362
$(NH_4)_2SO_4$	$BaSO_4$	1.7665	10.24611
	H_2SO_4	0.74224	9.87054
	N	0.21207	9.32648
	NH_3	0.25782	9.41131
	$(NH_4)_2PtCl_6$	3.3604	10.52639
	Pt	1.4772	10.16944
	SO_3	0.60587	9.78238
N_2O_5	NH_3	0.31531	9.49874
	NH_4NO_3	1.4821	10.17089
	$(NH_4)_2O$	0.48214	9.68317
Pt	NH_3	0.17449	9.24176
	NH_4	0.18484	9.26679
	NH_4NO_3	0.82018	9.91391
	$(NH_4)_2O$	0.26680	9.42619
	NH_4OH	0.35913	9.55524
	$(NH_4)_2SO_4$	0.67695	9.83056
SO_3	NH_3	0.42554	9.62894
	$(NH_4)_2SO_4$	1.6505	0.21762
Antimony: $Sb = 120.2$			
$KSbOC_4H_4O_6 \cdot \frac{1}{2}H_2O$	Sb	0.36168	9.55832
	Sb_2O_3	0.43390	9.63739
	Sb_2O_4	0.45796	9.66083
	Sb_2S_3	0.50640	9.70449
Sb	$KSbOC_4H_4O_6 \cdot \frac{1}{2}H_2O$	2.7649	10.44168
	Sb_2O_3	1.1997	10.07907
	Sb_2O_4	1.2662	10.10251
	Sb_2O_5	1.3328	10.12476
	Sb_2S_3	1.4001	10.14616
	Sb_2S_5	1.6639	10.22013
Sb_2O_3	$KSbOC_4H_4O_6 \cdot \frac{1}{2}H_2O$	2.3047	10.36261
	Sb	0.83355	9.92093
	Sb_2O_4	1.0555	10.02344
	Sb_2O_5	1.1109	10.04569
	Sb_2S_3	1.1671	10.06711
Antimony:			−10
Sb_2O_3	Sb_2S_5	1.3894	10.14283
Sb_2O_4	$KSbOC_4H_4O_6 \cdot \frac{1}{2}H_2O$	2.1886	10.33917
	Sb	0.78975	9.89749
	Sb_2O_3	0.94746	9.97656
	Sb_2O_5	1.0526	10.02225
	Sb_2S_3	1.1057	10.04364
	Sb_2S_5	1.3164	10.11939
Sb_2O_5	Sb	0.75031	9.87524
	Sb_2O_3	0.90014	9.95431
	Sb_2O_4	0.95006	9.97775
	Sb_2S_5	1.2506	10.09712
Sb_2S_3	$KSbOC_4H_4O_6 \cdot \frac{1}{2}H_2O$	1.9748	10.29553
	Sb	0.71424	9.85384
	Sb_2O_3	0.85685	9.93290
	Sb_2O_4	0.90439	9.95636
	Sb_2O_5	0.95192	9.97860
Sb_2S_5	Sb	0.59995	9.77812
	Sb_2O_3	0.71974	9.85718
	Sb_2O_4	0.75967	9.88063
	Sb_2O_5	0.79960	9.90287
Arsenic: $As = 74.96$			
As	As_2O_3	1.3202	10.12063
	As_2O_5	1.5336	10.18571
	As_2S_3	1.6415	10.21524
	As_2S_5	2.0692	10.31580
	$BaSO_4$	4.6711	10.66942
	$Mg_2As_2O_7$	2.0715	10.31629
	$MgNH_4AsO_4 \cdot \frac{1}{2}H_2O$	1.9227	10.28405
As_2O_3	As	0.75748	9.87937
	As_2O_5	1.1616	10.06508
	As_2S_3	1.2434	10.09461
	As_2S_5	1.5674	10.19518
	$BaSO_4$	3.5382	10.54878
	$Mg_2As_2O_7$	1.5691	10.19565
	$MgNH_4AsO_4 \cdot \frac{1}{2}H_2O$	1.9227	10.28405
As_2O_5	As	0.65203	9.81429
	As_2S_3	1.0704	10.02955
	As_2S_5	1.3493	10.13011
	$BaSO_4$	3.0458	10.48370
	$Mg_2As_2O_7$	1.3504	10.13057
	$MgNH_4AsO_4 \cdot \frac{1}{2}H_2O$	1.6556	10.21897
AsO_3	$BaSO_4$	2.8476	10.45448
	$Mg_2As_2O_7$	1.2629	10.10136
	$MgNH_4AsO_4 \cdot \frac{1}{2}H_2O$	1.5479	10.18975
AsO_4	$BaSO_4$	2.5198	10.40137
	$Mg_2As_2O_7$	1.1175	10.04823
	$MgNH_4AsO_4 \cdot \frac{1}{2}H_2O$	1.3700	10.13672
As_2S_3	As	0.60918	9.78475
	As_2O_3	0.80423	9.90538
	As_2O_5	0.93425	9.97046

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS
(Continued)

Weighed	Sought	Factor	Logarithm
Arsenic:			−10
As_2S_3	As_2S_5	1.2605	10.10054
	$Mg_2As_2O_7$	1.2619	10.10102
As_2S_5	As	0.48327	9.68419
	As_2O_3	0.63800	9.80482
	As_2O_5	0.73715	9.86756
$BaSO_4$	As	0.21408	9.33058
	As_2O_3	0.28263	9.45122
	As_2O_5	0.32832	9.51630
	AsO_3	0.35117	9.54552
	AsO_4	0.39686	9.59864
$Mg_2As_2O_7$	As	0.48273	9.68371
	As_2O_3	0.63730	9.80435
	As_2O_5	0.74033	9.86943
	AsO_3	0.79183	9.89864
	AsO_4	0.89490	9.95177
	As_2S_3	0.79244	9.89897
$MgNH_4AsO_4 \cdot \frac{1}{2}H_2O$	As	0.39383	9.59532
	As_2O_3	0.51993	9.71595
	As_2O_5	0.60399	9.78103
	AsO_3	0.64603	9.81025
	AsO_4	0.72993	9.86328
Barium: Ba = 137.37			
Ba	$BaCO_3$	1.4368	10.15739
	$BaCrO_4$	1.8457	10.26604
	$BaSiF_6$	2.0359	10.30876
	$BaSO_4$	1.6993	10.23027
$BaCl_2$	$BaCO_3$	0.94757	9.97661
	$BaCrO_4$	1.2170	10.08526
	$BaSO_4$	1.1207	10.04949
$BaCl_2 \cdot 2H_2O$	$BaSO_4$	0.95524	9.98019
$BaCO_3$	Ba	0.69610	9.84261
	$BaCl_2$	1.0551	10.02339
	$BaCrO_4$	1.2842	10.10865
	$Ba(HCO_3)_2$	1.3142	10.11867
	BaO	0.7707	9.89046
	$BaSO_4$	1.1827	10.07287
	CO_2	0.22293	9.34817
$BaCrO_4$	Ba	0.54195	9.73396
	$BaCl_2$	0.82175	9.91474
	$BaCO_3$	0.77866	9.89135
	BaO	0.60507	9.78181
BaF_2	$BaSiF_6$	1.5948	10.20270
$Ba(HCO_3)_2$	$BaCO_3$	0.76090	9.88133
$Ba(NO_3)_2$	$BaSO_4$	0.89303	9.95087
BaO	$BaCO_3$	1.2869	10.10954
	$BaCrO_4$	1.6526	10.21819
	$BaSiF_6$	1.8235	10.26091
	$BaSO_4$	1.5220	10.18241
	CO_2	0.28689	9.45771
BaO_2	$BaSO_4$	1.3782	10.13931
BaS	$BaSO_4$	1.3777	10.13915

Weighed	Sought	Factor	Logarithm
Barium:			−10
$BaSiF_6$	Ba	0.49118	9.69124
	BaF_2	0.62705	9.73909
	BaO	0.54839	9.79730
$BaSO_4$	Ba	0.58849	9.76974
	$BaCl_2$	0.89230	9.95051
	$BaCl_2 \cdot 2H_2O$	1.0467	10.01982
	$BaCO_3$	0.84554	9.92713
	$Ba(NO_3)_2$	1.1198	10.04914
	BaO	0.65703	9.81759
	BaO_2	0.72557	9.86068
	BaS	0.72583	9.86083
CO_2	BaO	3.4853	10.54224
	$BaCO_3$	4.4853	10.65179
Bismuth: Bi = 208			
Bi	Bi_2O_3	1.1154	10.04743
	BiOCl	1.2474	10.09601
	Bi_2S_3	1.2312	10.09033
$BiAsO_4$	Bi	0.59948	9.77778
	Bi_2O_3	0.66866	9.82521
$Bi(NO_3)_3 \cdot 5H_2O$	Bi_2O_3	0.47922	9.68054
	BiOCl	0.53594	9.72912
Bi_2O_3	Bi	0.89654	9.95257
	BiOCl	1.1184	10.04858
	$Bi(NO_3)_3 \cdot 5H_2O$	2.0867	10.31946
	$BiONO_3$	1.2328	10.09090
BiOCl	Bi	0.80166	9.90399
	$Bi(NO_3)_3 \cdot 5H_2O$	1.8658	10.27088
	Bi_2O_3	0.89417	9.95142
	$BiONO_3$	1.1024	10.04232
$BiONO_3$	Bi_2O_3	0.81115	9.90910
	BiOCl	0.90715	9.59768
Bi_2S_3	Bi	0.81221	9.90967
	Bi_2O_3	0.90593	9.95709
Boron: B = 11			
B	B_2O_3	3.1818	10.50268
	KBF_4	11.4640	11.05933
B_2O_3	B	0.31428	9.49732
	H_3BO_3	1.7721	10.24849
	KBF_4	3.6029	10.55665
	$Na_2B_4O_7 \cdot 10H_2O$	2.7297	10.43612
H_3BO_3	B_2O_3	0.56430	9.75151
	KBF_4	2.0331	10.30816
KBF_4	B	0.08723	8.94068
	B_2O_3	0.27755	9.44335
	H_3BO_3	0.49186	9.69184
	$Na_2B_4O_7 \cdot 10H_2O$	0.75765	9.87947
Bromine: Br = 79.92			
Ag	Br	0.74083	9.86972
	BrO_3	1.1858	10.07400
	HBr	0.75053	9.87537

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS (Continued)

Weighed	Sought	Factor	Logarithm
Bromine:			−10
AgBr	Br	0.42556	9.62896
	BrO_3	0.68114	9.83324
	HBr	0.43113	9.63461
Br	Ag	1.3498	10.13029
	AgBr	2.3498	10.37104
	O	0.10009	9.00038
BrO_3	Ag	0.84333	9.92600
	AgBr	1.4681	10.16676
HBr	Ag	1.3324	10.12463
	AgBr	2.3195	10.36539
O	Br	9.9913	10.99962
Cadmium: Cd = 112.4			
Cd	$CdCl_2$	1.6308	10.21239
	CdO	1.1426	10.05780
	CdS	1.2852	10.10897
	$CdSO_4$	1.8546	10.26825
$CdCl_2$	Cd	0.61321	9.78761
	CdO	0.70051	9.84541
	CdS	0.78802	9.89654
	$CdSO_4$	1.1371	10.05580
$Cd(NO_3)_2$	Cd	0.47543	9.67708
	CdO	0.54310	9.73488
	CdS	0.61103	9.78600
	$CdSO_4$	0.88173	9.94534
CdO	Cd	0.87539	9.94220
	$CdCl_2$	1.4276	10.15459
	$Cd(NO_3)_2$	1.8413	10.26512
	CdS	1.1251	10.05119
	$CdSO_4$	1.6235	10.21045
CdS	Cd	0.77807	9.89102
	$CdCl_2$	1.2690	10.10346
	$Cd(NO_3)_2$	1.6366	10.21394
	CdO	0.88883	9.94882
$CdSO_4$	Cd	0.53919	9.73174
	$CdCl_2$	0.87940	9.94419
	$Cd(NO_3)_2$	1.1341	10.05465
	CdO	0.61595	9.78955
Calcium: Ca = 40.07			
$BaSO_4$	CaS	0.30900	9.48996
	$CaSO_4$	0.58317	9.76580
	$CaSO_4 \cdot 2H_2O$	0.73752	9.86777
Ca	$CaCl_2$	2.7699	10.44246
	$CaCO_3$	2.4974	10.39748
	CaO	1.3993	10.14591
	$CaSO_4$	3.3973	10.53113
	Cl	1.7699	10.24795
$Ca_3(AsO_4)_2$	$Mg_2As_2O_7$	0.77995	9.89207
$CaCl_2$	Ca	0.36103	9.55754
	$CaCO_3$	0.90162	9.95502
	CaO	0.50518	9.70345
	$CaSO_4$	1.2265	10.08867
	Cl	0.63899	9.80549
$CaCO_3$	Ca	0.40043	9.60252

Weighed	Sought	Factor	Logarithm
Calcium:			−10
$CaCO_3$	$CaCl_2$	1.1091	10.04498
	$Ca(HCO_3)_2$	1.6198	10.20945
	CaO	0.56031	9.74843
	$CaSO_4$	1.3602	10.13360
	$CaSO_4 \cdot 2H_2O$	1.7204	10.23563
	HCl	0.72890	9.86267
CaF_2	$CaSO_4$	1.7437	10.24147
$Ca(HCO_3)_2$	$CaCO_3$	0.61737	9.79055
	CaO	0.34592	9.53898
$Ca(NO_3)_2$	N_2O_5	0.65830	9.81842
CaO	Ca	0.71465	9.85409
	$CaCl_2$	1.9793	10.29652
	$CaCO_3$	1.7847	10.25157
	$Ca(HCO_3)_2$	2.8908	10.46102
	$Ca_3(PO_4)_2$	1.8449	10.26593
	$CaSO_4$	2.4279	10.38523
	$CaSO_4 \cdot 2H_2O$	3.0687	10.48695
	Cl	1.2649	10.10204
	MgO	0.71910	9.85679
	SO_3	1.4279	10.15470
$Ca_3(PO_4)_2$	CaO	0.54209	9.73407
	$CaSO_4$	1.3162	10.11932
	$Mg_2P_2O_7$	0.71777	9.85598
	$(NH_4)_3PO_4 \cdot 12MoO_3$	12.0989	11.08275
	P_2O_5	0.45787	9.66075
CaS	$BaSO_4$	3.2362	10.51003
$CaSO_4$	$BaSO_4$	1.7148	10.23421
	Ca	0.29435	9.46886
	$CaCl_2$	0.81532	9.91133
	$CaCO_3$	0.73511	9.86635
	CaF_2	0.57350	9.75853
	CaO	0.41189	9.61478
	SO_3	0.58811	9.76946
$CaSO_4 \cdot 2H_2O$	$BaSO_4$	1.3559	10.13223
	$CaCO_3$	0.58126	9.76437
	CaO	0.32569	9.51280
	SO_3	0.46503	9.66748
$CaWO_4$	WO_3	0.80530	9.90596
Cl	Ca	0.56500	9.75205
	$CaCl_2$	1.5650	10.19451
	CaO	0.79060	9.89796
CO_2	CaO	1.2743	10.10528
	$CaCO_3$	2.2743	10.35685
HCl	$CaCO_3$	1.3719	10.13733
$Mg_2As_2O_7$	$Ca_3(AsO_4)_2$	1.2821	10.10793
MgO	CaO	1.3906	10.14321
$Mg_2P_2O_7$	$Ca_3(PO_4)_2$	1.3932	10.14402
$(NH_4)_3PO_4 \cdot 12MoO_3$	$Ca_3(PO_4)_2$	0.08265	8.91725
N_2O_5	$Ca(NO_3)_2$	1.5191	10.18158
P_2O_5	$Ca_3(PO_4)_2$	2.1840	10.33925
SO_3	CaO	0.70035	9.84532

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS
(Continued)

Weighed	Sought	Factor	Logarithm
Calcium:			−10
SO_3	$CaSO_4$	1.7003	10.23053
	$CaSO_4 \cdot 2H_2O$	2.1504	10.33252
WO_3	$CaWO_4$	1.2418	10.09404
Carbon: C = 12.005			
Ag	HCN	0.25049	9.39879
	KCN	0.60359	9.78074
AgCN	HCN	0.20182	9.30496
	KCN	0.48631	9.68691
$BaCO_3$	C	0.06082	8.78390
	CO_2	0.22295	9.34819
	CO_3	0.30402	9.48290
BaO	CO_2	0.28692	9.45776
	CO_2, bicarbonate	0.57384	9.75879
C	$BaCO_3$	16.4411	11.21593
	CO_2	3.6656	10.56414
$CaCO_3$	CO_2	0.43972	9.64318
$Ca(HCO_3)_2$	CO_2	0.54295	9.73476
CaO	CO_2	0.78482	9.89477
	CO_2, bicarbonate	1.5696	10.19579
CO_2	$BaCO_3$	4.4863	10.65189
	$Ba(HCO_3)_2$	2.9473	10.46942
	BaO	3.4853	10.54224
	C	0.27281	9.43586
	$CaCO_3$	2.2742	10.35683
	$Ca(HCO_3)_2$	1.8416	10.26519
	CaO	1.2742	10.10524
	CO_3	1.3636	10.13469
	$FeCO_3$	2.6325	10.42037
	$Fe(HCO_3)_2$	2.0210	10.30557
	K_2CO_3	3.1407	10.49703
	$KHCO_3$	2.2751	10.35700
	K_2O	2.1407	10.33056
	Li_2CO_3	1.6790	10.22505
	$LiHCO_3$	1.5443	10.18873
	Li_2O	0.67901	9.83188
	$MgCO_3$	1.9163	10.28246
	$Mg(HCO_3)_2$	1.6628	10.22084
	MgO	0.91626	9.96202
	$MnCO_3$	2.6119	10.41696
	$Mn(HCO_3)_2$	2.0106	10.30333
	MnO	1.6119	10.20734
	Na_2CO_3	2.4089	10.38182
	$NaHCO_3$	1.9092	10.28085
	Na_2O	1.4089	10.14888
	$(NH_4)_2CO_3$	2.1836	10.33917
	NH_4HCO_3	1.7965	10.25443
	$PbCO_3$	6.0721	10.78334
	$SrCO_3$	3.3550	10.52569
	$Sr(HCO_3)_2$	2.3822	10.37698
	SrO	2.3550	10.37199
CO_3	$BaCO_3$	3.2892	10.51709
	CO_2	0.73336	9.86532

Weighed	Sought	Factor	Logarithm
Carbon:			−10
$FeCO_3$	CO_2	0.37986	9.57962
$Fe(HCO_3)_2$	CO_2	0.49481	9.69444
HCN	Ag	3.9922	10.60121
	AgCN	4.9549	10.69503
KCN	Ag	1.6568	10.21927
	AgCN	2.0563	10.31309
K_2CO_3	CO_2	0.31840	9.50297
$KHCO_3$	CO_2	0.43954	9.64300
K_2O	CO_2	0.46714	9.66945
Li_2CO_3	CO_2	0.59559	9.77495
$LiHCO_3$	CO_2	0.64756	9.81128
Li_2O	CO_2	1.4727	10.16711
$MgCO_3$	CO_2	0.52185	9.71755
$Mg(HCO_3)_2$	CO_2	0.60139	9.77916
MnO	CO_2	0.62035	9.79264
Na_2CO_3	CO_2	0.41512	9.61817
$NaHCO_3$	CO_2	0.52378	9.71915
Na_2O	CO_2	0.70976	9.85111
$(NH_4)_2CO_3$	CO_2	0.45796	9.66083
NH_4HCO_3	CO_2	0.55664	9.74557
$PbCO_3$	CO_2	0.16469	9.21667
$SrCO_3$	CO_2	0.29807	9.47432
$Sr(HCO_3)_2$	CO_2	0.41978	9.62302
SrO	CO_2	0.42463	9.62801
Chlorine: Cl = 35.46			
Ag	Cl	0.32870	9.51680
	HCl	0.33796	9.52886
AgCl	Cl	0.24738	9.39337
	HCl	0.25435	9.40543
$BaCrO_4$	Cl	0.27988	9.44697
Ca	Cl	1.7699	10.24795
Cl	Ag	3.0423	10.48320
	AgCl	4.0423	10.60663
	$BaCrO_4$	3.5730	10.55303
	Ca	0.56500	9.75205
	HCl	1.0284	10.01216
	K	1.1027	10.04244
	KCl	2.1026	10.32277
	Li	0.19579	9.29162
	Mg	0.34292	9.53519
	$MgCl_2$	1.3430	10.12805
	MnO_2	1.2257	10.08840
	Na	0.64862	9.81199
	NaCl	1.6486	10.21712
	NH_4	0.50874	9.70650
	$PbCrO_4$	4.5572	10.65870
HCl	Ag	2.9590	10.47114
	AgCl	3.9316	10.59457
	NH_4Cl	1.4669	10.16641
	$(NH_4)_2SO_4$	1.8116	10.25806
K	Cl	0.90691	9.95756
KCl	Cl	0.47558	9.67723

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS (Continued)

Weighed	Sought	Factor	Logarithm
Chlorine:			−10
Li	Cl	5.10947	10.70838
Mg	Cl	2.9162	10.46481
$MgCl_2$	Cl	0.74465	9.87195
MnO_2	Cl	0.81583	9.91160
Na	Cl	1.5417	10.18801
NaCl	Cl	0.60657	9.78288
NH_4	Cl	1.9656	10.29350
$PbCrO_4$	Cl	0.21943	9.34130
Chromium: Cr = 52			
$BaCrO_4$	Cr	0.20529	9.31236
	Cr_2O_3	0.29992	9.47707
	CrO_3	0.39469	9.59626
	CrO_4	0.45784	9.66072
	$Cr_2(SO_4)_3 \cdot 18H_2O$	1.4139	10.15042
Cr	$BaCrO_4$	4.8712	10.68764
	Cr_2O_3	1.46154	10.16481
	$PbCrO_4$	6.2154	10.79347
Cr_2O_3	$BaCrO_4$	3.33389	10.52293
	Cr	0.68422	9.83519
	CrO_3	1.31570	10.11919
CrO_3	$BaCrO_4$	2.5336	10.40376
	Cr_2O_3	0.76000	9.88081
	K_2CrO_4	1.9420	10.28825
	$K_2Cr_2O_7$	1.4693	10.16731
	$PbCrO_4$	3.2320	10.50947
CrO_4	$BaCrO_4$	2.1842	10.33928
	$PbCrO_4$	2.7862	10.44501
$Cr_2(SO_4)_3 \cdot 18H_2O$	$BaCrO_4$	0.70727	9.84959
	$PbCrO_4$	0.90220	9.95530
K_2CrO_4	CrO_3	0.51494	9.71175
	$PbCrO_4$	1.6637	10.22108
$K_2Cr_2O_7$	CrO_3	0.68028	9.83269
	$PbCrO_4$	2.1971	10.34185
$PbCrO_4$	Cr	0.16089	9.20653
	Cr_2O_3	0.23515	9.37135
	CrO_3	0.30941	9.49053
	CrO_4	0.35891	9.55499
	$Cr_2(SO_4)_3 \cdot 18H_2O$	1.1084	10.04470
	K_2CrO_4	0.60087	9.77878
	$K_2Cr_2O_7$	0.45514	10.65815
Cobalt: Co = 58.97			
Co	$Co(NO_3)_2 \cdot 6H_2O$	4.9361	10.69339
	$Co(NO_2)_3(KNO_2)_3$	7.6706	10.88483
	CoO	1.2714	10.10426
	Co_3O_4	1.3618	10.13411
	$CoSO_4$	2.6290	10.41979
	$CoSO_4 \cdot 7H_2O$	4.7675	10.67829
	$(CoSO_4)_2(K_2SO_4)_3$	7.0616	10.84890

Weighed	Sought	Factor	Logarithm
Cobalt:			−10
$Co(NO_3)_2 \cdot 6H_2O$	Co	0.20258	9.30661
$Co(NO_2)_3(KNO_2)_3$	Co	0.13037	9.11517
	CoO	0.16574	9.21943
CoO	Co	0.78657	9.89574
	$Co(NO_2)_3(KNO_2)_3$	6.0335	10.78057
	Co_3O_4	1.0711	10.02985
	$CoSO_4$	2.0679	10.31553
	$(CoSO_4)_2(K_2SO_4)_3$	5.5545	10.74465
Co_3O_4	Co	0.73433	9.86890
	CoO	0.93358	9.97015
$CoSO_4$	Co	0.38038	9.58022
	CoO	0.48358	9.68447
$CoSO_4 \cdot 7H_2O$	Co	0.20975	9.32170
	CoO	0.26666	9.42596
$(CoSO_4)_2(K_2SO_4)_3$	Co	0.1416	9.15109
	CoO	0.18003	9.25534
Copper: Cu = 63.57			
Cu	$Cu_2\left\{C_2H_3O_2 \cdot (AsO_2)_3\right\}$	3.9880	10.60076
	CuCNS	1.9136	10.28185
	CuO	1.2517	10.09750
	Cu_2O	1.1258	10.05147
	Cu_2S	1.2522	10.09767
	$CuSO_4 \cdot 5H_2O$	3.9281	10.59418
$Cu\left\{C_2H_3O_2(AsO_2)_3\right\}$	Cu	0.25075	9.39924
	$Mg_2As_2O_7$	0.91874	9.96319
CuCNS	Cu	0.52259	9.71816
	CuO	0.65412	9.81566
CuO	Cu	0.79891	9.90250
	CuCNS	1.5288	10.18435
	Cu_2S	1.0004	10.00017
	$CuSO_4 \cdot 5H_2O$	3.1382	10.49668
Cu_2O	Cu	0.88824	9.94853
	Cu_2S	1.1122	10.04618
$CuSO_4 \cdot 5H_2O$	Cu	0.25458	9.40582
	CuO	0.31865	9.50331
	Cu_2S	0.31877	9.50348
$Mg_2As_2O_7$	$Cu_2\left\{C_2H_3O_2(AsO_2)_3\right\}$	1.0885	10.03681

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS
(Continued)

Weighed	Sought	Factor	Logarithm
Fluorine:			
F = 19			−10
BaF_2	$BaSiF_6$	1.5948	10.20270
$BaSiF_6$	BaF_2	0.62705	9.79730
	F	0.40762	9.61025
	HF	0.42924	9.63270
	H_2SiF_6	0.51602	9.71267
	SiF_4	0.37294	9.57163
	SiF_6	0.50880	9.70655
CaF_2	F	0.48675	9.68730
	HF	0.51258	9.70976
	H_2SiF_6	1.6228	10.21028
$CaSO_4$	F	0.27914	9.44582
	HF	0.29395	9.46827
F	$BaSiF_6$	2.45330	10.38975
	CaF_2	2.05447	10.31270
	$CaSO_4$	3.5824	10.55417
	H_2SiF_6	1.2660	10.10242
	K_2SiF_6	1.9342	10.28651
HF	$BaSiF_6$	2.3297	10.36730
	CaF_2	1.9509	10.29024
	$CaSO_4$	3.4019	10.53172
	K_2SiF_6	1.8368	10.26406
2HF	H_2SiF_6	3.6065	10.55708
6HF	H_2SiF_6	1.2022	10.07997
H_2SiF_6	$BaSiF_6$	1.93790	10.28733
	CaF_2	0.61620	9.78972
	F	0.78992	9.89758
	2HF	0.27728	9.44292
	6HF	0.83182	9.92003
	SiF_4	0.72270	9.85896
	SiF_6	0.98601	9.99388
KF	K_2SiF_6	1.8976	10.27820
K_2SiF_6	F	0.51700	9.71349
	HF	0.54443	9.73594
	H_2SiF_6	0.65451	9.81598
	KF	0.52699	9.72180
	SiF_6	0.64534	9.80979
SiF_4	$BaSiF_6$	2.6814	10.42837
	H_2SiF_6	1.3837	10.14104
SiF_6	$BaSiF_6$	1.9654	10.29345
	H_2SiF_6	1.0141	10.00612
	K_2SiF_6	1.5495	10.19021
Gold:			
Au = 197.2			
Au	$AuCl_3$	1.5394	10.18736
	$HAuCl_4 \cdot 4H_2O$	2.0898	10.32010
	$KAu(CN)_4 \cdot H_2O$	1.8172	10.25941
$AuCl_3$	Au	0.64959	9.81264
$HAuCl_4 \cdot 4H_2O$	Au	0.47852	9.67990
$KAu(CN)_4 \cdot H_2O$	Au	0.55028	9.74059
Hydrogen:			
H = 1.008			
H	H_2O	8.9363	10.95116

Weighed	Sought	Factor	Logarithm
Hydrogen:			−10
H	O	7.9365	10.89963
H_2O	H	0.11190	9.04884
O	H	0.12595	9.10020
Iodine:			
I = 126.92			
Ag	HI	1.1859	10.07403
	I	1.1765	10.07059
AgI	HI	0.54484	9.73627
	I	0.54055	9.73283
	IO_3	0.74497	9.87214
	IO_4	0.81313	9.91016
	I_2O_5	0.71091	9.85181
	I_2O_7	0.77904	9.89156
HI	Ag	0.84328	9.92597
	AgI	1.8354	10.26373
	Pd	0.41703	9.62016
	PdI_2	1.4092	10.14896
	TlI	2.5868	10.41276
I	Ag	0.84998	9.92941
	AgI	1.8500	10.26717
	Pd	0.42034	9.62360
	PdI_2	1.4204	10.15240
	TlI	2.6074	10.41620
IO_3	AgI	1.3423	10.12786
	PdI_2	1.0306	10.01309
IO_4	AgI	1.2298	10.08984
	PdI_2	0.94421	9.97507
	TlI	1.7333	10.23887
I_2O_5	AgI	1.4067	10.14819
	PdI_2	1.0799	10.03342
	TlI	1.9825	10.29722
I_2O_7	AgI	1.2836	10.10844
	PdI_2	0.98553	9.99361
	TlI	1.8091	10.25747
Pd	HI	2.3979	10.37984
	I	2.3790	10.37640
PdI_2	HI	0.70965	9.85104
	I	0.70404	9.84760
	IO_3	0.97031	9.98691
	IO_4	1.0591	10.02493
	I_2O_5	0.92593	9.96658
	I_2O_7	1.0147	10.00633
TlI	HI	0.38658	9.58724
	I	0.38353	9.58380
	IO_3	0.52858	9.72311
	IO_4	0.57694	9.76113
	I_2O_5	0.50440	9.70278
	I_2O_7	0.55275	9.74253
Iron:			
Fe = 55.84			
Ag	$Fe_7(CN)_{18}$, prussian blue	0.44240	9.64582
CN	$Fe_7(CN)_{18}$	1.8349	10.26362
CO_2	FeO	1.6325	10.21285
	$FeCO_3$	2.6325	10.42037
	$Fe(HCO_3)_2$	2.0210	10.30557

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS (Continued)

Weighed	Sought	Factor	Logarithm
Iron:			−10
Fe	$Fe(HCO_3)_2$	3.1851	10.50313
	FeO	1.2865	10.10943
	Fe_2O_3	1.4298	10.15527
	$FePO_4$	2.7020	10.43168
	FeS	1.5741	10.19703
	$FeSO_4$	2.7203	10.43462
	$FeSO_4 \cdot 7H_2O$	4.9787	10.69712
	$FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$	7.0227	10.84650
$FeAsO_4$	$Mg_2As_2O_7$	0.79714	9.90162
$FeCl_3$	Fe_2O_3	0.49211	9.69212
$Fe_7(CN)_{18}$, prussian blue	Ag	2.26036	10.35418
	CN	0.54496	9.73637
$FeCO_3$	CO_2	0.37986	9.57962
	FeO	0.62017	9.79251
	Fe_2O_3	0.68924	9.83836
$Fe(HCO_3)_2$	CO_2	0.49480	9.69443
	Fe	0.31396	9.49687
	FeO	0.40392	9.60629
	Fe_2O_3	0.44889	9.65214
FeO	CO_2	0.61254	9.78713
	Fe	0.77728	9.89058
	$FeCO_3$	1.6124	10.20749
	$FeHCO_3$	2.47577	10.39371
	Fe_2O_3	1.1114	10.04585
	$FePO_4$	2.1002	10.32226
	FeS	1.2236	10.08764
	SO_3	1.1144	10.04704
Fe_3O_4	Fe_2O_3	1.0346	10.01477
Fe_2O_3	Fe	0.69940	9.84473
	$FeCl_3$	2.0318	10.30788
	$FeCO_3$	1.4509	10.16164
	$Fe(HCO_3)_2$	2.2278	10.34786
	$Fe(HCO_3)_2$	2.2278	10.34786
	FeO	0.89980	9.95415
	Fe_3O_4	0.96657	9.98523
	$FePO_4$	1.8898	10.27641
	FeS	1.1010	10.04179
	$FeSO_4$	1.9026	10.27935
	$FeSO_4 \cdot 7H_2O$	3.4821	10.54184
	$FeSO_4 (NH_4)_2SO_4 \cdot 6H_2O$	4.91157	10.69122
	$Fe_2(SO_4)_3$	2.5041	10.39865
$FePO_4$	Fe	0.37010	9.56832
	FeO	0.47615	9.67774
	Fe_2O_3	0.52920	9.72362
FeS	Fe	0.63527	9.80296
	FeO	0.81729	9.91238
	Fe_2O_3	0.90830	9.95823
$FeSO_4$	Fe	0.36761	9.56539
	Fe_2O_3	0.52561	9.72066
	SO_3	0.52706	9.72186
Iron:			−10
$FeSO_4 \cdot 7H_2O$	Fe	0.20086	9.30289
	Fe_2O_3	0.28718	9.45815
$FeSO_4 \cdot (NH_4)_2 SO_4 \cdot 6H_2O$	Fe	0.14239	9.15348
	Fe_2O_3	0.20360	9.30878
$Fe_2(SO_4)_3$	Fe_2O_3	0.39934	9.60134
$Mg_2As_2O_7$	$FeAsO_4$	1.2542	10.09838
SO_3	FeO	0.89733	9.95295
	$FeSO_4$	1.8973	10.27814
Lead: $Pb = 207.2$			
$BaSO_4$	$PbSO_4$	1.2991	10.11364
Pb	$PbCl_2$	1.3375	10.12629
	$PbCO_3$	1.2896	10.11045
	$(PbCO_3)_2 \cdot Pb(OH)_2$	1.2478	10.09601
	$PbCrO_4$	1.5598	10.19307
	PbO	1.0772	10.03230
	PbO_2	1.1544	10.06236
	PbS	1.1547	10.06247
	$PbSO_4$	1.4636	10.16542
$PbCl_2$	Pb	0.74500	9.87216
	PbO	0.80253	9.90447
$Pb(C_2H_3O_2)_2\ 3H_2O$	$PbCrO_4$	0.85210	9.93049
	$PbSO_4$	0.79953	9.90283
$PbCO_3$	Pb	0.77545	9.88955
	PbO	0.83533	9.92186
	$PbSO_4$	1.1350	10.05500
$(PbCO_3)_2 \cdot Pb(OH)_2$	Pb	0.80142	9.90386
	$PbCrO_4$	1.2501	10.09694
	$PbSO_4$	1.1730	10.06930
$PbCrO_4$	Pb	0.64109	9.80692
	$Pb(C_2H_3O_2)_2 \cdot 3H_2O$	1.1736	10.06952
	$(PbCO_3)_2 \cdot Pb(OH)_2$	0.79994	9.90306
	PbO	0.69059	9.83922
	Pb_3O_4	0.70710	9.84948
	$PbSO_4$	0.93830	9.97234
$Pb(NO_3)_2$	PbO	0.67387	9.82858
	PbO_2	0.72218	9.85865
	$PbSO_4$	0.91558	9.96170
PbO	Pb	0.92832	9.96770
	$PbCl_2$	1.2461	10.09556
	$PbCO_3$	1.1967	10.07799
	$PbCrO_4$	1.4480	10.16077
	$Pb(NO_3)_2$	1.4840	10.17143
	PbS	1.0720	10.03019
	$PbSO_4$	1.3587	10.13312
PbO_2	Pb	0.86622	9.93763
	$Pb(NO_3)_2$	1.3847	10.14136

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS (Continued)

Weighed	Sought	Factor	Logarithm
Lead:			−10
PbO_2	$PbSO_4$	1.2678	10.10305
Pb_3O_4	PbC_2O_4	1.4142	10.15051
	$PbSO_4$	1.3270	10.12287
$Pb(OH)_2$	Pb	0.85898	9.93398
PbS	Pb	0.86580	9.93742
	PbO	0.93288	9.96983
	$PbSO_4$	1.2675	10.10295
$PbSO_4$	$BaSO_4$	0.76974	9.88634
	Pb	0.68324	9.83457
	$Pb(C_2H_3O_2)_2 \cdot 3H_2O$	1.2508	10.09721
	$PbCO_3$	0.88109	9.94502
	$(PbCO_3)_2 \cdot Pb(OH)_2$	0.85254	9.93071
	$PbCrO_4$	1.0658	10.02768
	$Pb(NO_3)_2$	1.0922	10.03830
	PbO	0.73600	9.86688
	PbO_2	0.78876	9.89694
	Pb_3O_4	0.75359	9.87714
	PbS	0.78896	9.89706
Lithium: Li = 6.94			
CO_2	Li_2CO_3	1.6790	10.22505
	$LiHCO_3$	1.5443	10.18873
	Li_2O	0.67901	9.83188
Li	LiCl	6.1096	10.78601
	Li_2CO_3	5.3227	10.72614
	Li_2O	2.1539	10.33322
	Li_3PO_4	5.5629	10.74530
	Li_2SO_4	7.9207	10.89876
LiCl	Li	0.16368	9.21399
	Li_2CO_3	0.87124	9.94013
	Li_2O	0.35227	9.54698
	Li_3PO_4	0.91052	9.95929
	Li_2SO_4	1.2965	10.11277
Li_2CO_3	CO_2	0.59559	9.77495
	Li	0.18789	9.27386
	LiCl	1.1479	10.05987
	$LiHCO_3$	1.8395	10.26469
	Li_2O	0.40444	9.60685
	Li_3PO_4	1.0451	10.01916
$LiHCO_3$	CO_2	0.64756	9.81128
	Li_2CO_3	0.54366	9.73531
	Li_2O	0.21960	9.34216
Li_2O	CO_2	1.4727	10.16811
	Li	0.46427	9.66678
	LiCl	2.8381	10.45302
	Li_2CO_3	2.4630	10.39315
	$LiHCO_3$	4.5482	10.65784
	Li_3PO_4	2.5842	10.41231
	Li_2SO_4	3.6794	10.56578
	SO_3	2.6794	10.42804
Li_3PO_4	Li	0.17976	9.25470
	LiCl	1.0983	10.04071
	$LiCO_3$	0.95689	9.98084
	$LiHCO_3$	1.7601	10.24553
	Li_2O	0.38700	9.58769
	Li_2SO_4	1.4234	10.15333

Weighed	Sought	Factor	Logarithm
Lithium:			−10
Li_3PO_4	$Li_2SO_4 \cdot H_2O$	1.6572	10.21937
Li_2SO_4	Li	0.12625	9.10123
	LiCl	0.77133	9.88724
	Li_2O	0.27178	9.43422
SO_3	Li_2O	0.37322	9.57196
	Li_2SO_4	1.3732	10.13773
Magnesium: Mg = 24.32			
$BaSO_4$	$MgSO_4$	0.51570	9.71240
	$MgSO_4 \cdot 7H_2O$	1.0559	10.02362
Br	Mg	0.15213	9.18222
	$MgBr_2$	1.1520	10.06146
	$MgBr_2 \cdot 6H_2O$	1.8282	10.26203
Cl	Mg	0.34292	9.53519
	$MgCl_2$	1.3430	10.12805
	$MgCl_2 \cdot 6H_2O$	2.8672	10.45746
CO_2	$MgCO_3$	1.9163	10.28246
	MgO	0.91626	9.96202
I	Mg	0.09581	8.98140
	MgI_2	1.0958	10.03973
Mg	Br	6.5732	10.81778
	Cl	2.9162	10.46481
	I	10.4380	11.01860
	MgO	1.6579	10.21956
	$Mg_2P_2O_7$	4.5790	10.66077
	$MgSO_4$	4.9449	10.69459
$MgBr_2$	Br	0.86806	9.93855
$MgBr_2 \cdot 6H_2O$	Br	0.54698	9.73797
$MgCl_2$	Cl	0.74465	9.87195
	$Mg_2P_2O_7$	1.1692	10.06791
$MgBr_2 \cdot 6H_2O$	Br	0.54698	9.73797
$MgCl_2 \cdot 6H_2O$	Cl	0.34877	9.54250
	$Mg_2P_2O_7$	0.54765	9.73854
$MgCl_2 \cdot KCl \cdot 6H_2O$	$Mg_2P_2O_7$	0.40072	9.60284
$MgCO_3$	CO_2	0.52185	9.71755
	$Mg(HCO_3)_2$	1.7355	10.23943
	MgO	0.47818	9.67959
	$Mg_2P_2O_7$	1.3206	10.12080
$Mg(HCO_3)_2$	$MgCO_3$	0.57619	9.76057
	MgO	0.27553	9.44016
	$Mg_2P_2O_7$	0.76097	9.88137
MgI_2	I	0.91258	9.96027
MgO	CO_2	1.0914	10.03798
	Mg	0.60317	9.78044
	$MgCO_3$	2.0912	10.32041
	$Mg(HCO_3)_2$	3.6294	10.55984
	$Mg_2P_2O_7$	2.7619	10.44121
	$MgSO_4$	2.9856	10.47503
$Mg_2P_2O_7$	Mg	0.21839	9.33923

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS (Continued)

Weighed	Sought	Factor	Logarithm
Magnesium:			−10
$Mg_2P_2O_7$	$MgCl_2$	0.85524	9.93209
	$MgCl_2 \cdot 6H_2O$	1.8260	10.26150
	$MgCl_2 \cdot KCl \cdot 6H_2O$	2.4955	10.39716
	$MgCO_3$	0.75719	9.87920
	$Mg(HCO_3)_2$	1.3141	10.11862
	MgO	0.36207	9.55879
	$MgSO_4$	1.0810	10.03383
	$MgSO_4 \cdot 7H_2O$	2.2135	10.34508
$MgSO_4$	$BaSO_4$	1.9391	10.28760
	Mg	0.20203	9.30542
	MgO	0.33494	9.52497
	$Mg_2P_2O_7$	0.92507	9.96617
	SO_3	0.66506	9.82286
$MgSO_4 \cdot 7H_2O$	$BaSO_4$	0.94702	9.97636
	$Mg_2P_2O_7$	0.45178	9.65493
	SO_3	0.32480	9.51162
SO_3	MgO	0.50362	9.70210
	$MgSO_4$	1.5036	10.17713
	$MgSO_4 \cdot 7H_2O$	3.0788	10.48838
Manganese: Mn = 54.93			
$BaSO_4$	$MnSO_4$	0.64687	9.81082
CO_2	$MnCO_3$	2.6119	10.41696
	MnO	1.6119	10.20734
Mn	$MnCO_3$	2.0923	10.32062
	MnO	1.2913	10.11102
	Mn_2O_3	1.4369	10.15744
	Mn_3O_4	1.3884	10.14251
$MnCO_3$	CO_2	0.38287	9.58305
	Mn	0.47795	9.67938
	MnO	0.61716	9.79040
	Mn_3O_4	0.66358	9.82189
	$Mn_2P_2O_7$	1.2353	10.09177
	MnS	0.75690	9.87904
$Mn(HCO_3)_2$	$MnCO_3$	0.64950	9.81258
	MnO	0.40084	9.60298
	Mn_3O_4	0.43099	9.63447
MnO	CO_2	0.62040	9.79267
	Mn	0.77442	9.88898
	$MnCO_3$	1.6203	10.20960
	$MnHCO_3$	2.4947	10.39702
	Mn_2O_3	1.1128	10.04641
	Mn_3O_4	1.0752	10.03149
	$Mn_2P_2O_7$	2.0016	10.30137
	MnS	1.2264	10.08863
	SO_3	1.1287	10.05258
Mn_2O_3	Mn	0.69593	9.84256
	MnO	0.89865	9.95359
	Mn_3O_4	0.96623	9.98508
Mn_3O_4	Mn	0.72026	9.85749
	$MnCO_3$	1.5070	10.17811
	$Mn(HCO_3)_2$	2.3203	10.36553

Weighed	Sought	Factor	Logarithm
Manganese:			−10
Mn_3O_4	MnO	0.93006	9.96851
	Mn_2O_3	1.0349	10.01492
	MnO_2	1.1398	10.05685
	$MnSO_4$	1.9803	10.29673
MnO_2	Mn_3O_4	0.87730	9.94315
	$Mn_2P_2O_7$	1.6332	10.21303
$Mn_2P_2O_7$	Mn	0.38691	9.58761
	$MnCO_3$	0.80952	9.90823
	MnO	0.49961	9.69863
	MnO_2	0.61231	9.78697
	$MnSO_4$	1.0635	10.02674
MnS	Mn	0.63145	9.80034
	$MnCO_3$	1.3212	10.12097
	MnO	0.81538	9.91136
	$MnSO_4$	1.7357	10.23947
$MnSO_4$	$BaSO_4$	1.5460	10.18921
	Mn_3O_4	0.50509	9.70337
	$Mn_2P_2O_7$	0.94026	9.97325
	MnS	0.57613	9.76052
	SO_3	0.53023	9.72446
SO_3	MnO	0.88596	9.94741
	$MnSO_4$	1.8860	10.27554
Mercury: Hg = 200.6			
Hg	$HgCl$	1.1768	10.07069
	$HgCl_2$	1.3535	10.13147
	HgO	1.0797	10.03330
	HgS	1.1598	10.06438
$HgCl$	Hg	0.84978	9.92931
	$HgCl_2$	1.1502	10.06078
	$HgNO_3$	1.1102	10.04538
	Hg_2O	0.88364	9.94629
	HgO	0.91756	9.96264
	HgS	0.98560	9.99370
$HgCl_2$	Hg	0.73880	9.86853
	$HgCl$	0.86940	9.93922
	HgS	0.85688	9.94292
$Hg(CN)_2$	HgS	0.92097	9.96425
$HgNO_3$	$HgCl$	0.90078	9.95462
	HgS	0.88595	9.94741
$Hg(NO_3)_2$	HgS	0.71672	9.85535
$Hg(NO_3)_2 \cdot H_2O$	HgS	0.67902	9.83188
Hg_2O	$HgCl$	1.1317	10.05371
	HgS	1.1153	10.04739
HgO	Hg	0.92612	9.96667
	$HgCl$	1.0898	10.03736
	HgS	1.0741	10.03104
HgS	$HgCl_2$	1.1670	10.06707
	$Hg(CN)_2$	1.0858	10.03575
	$HgNO_3$	1.1287	10.05258
	$Hg(NO_3)_2$	1.3953	10.14467
	$Hg(NO_3)_2 \cdot H_2O$	1.4727	10.16711
	Hg_2O	0.89659	9.95259
	HgO	0.93097	9.96894
	$HgSO_4$	1.2751	10.10554
$HgSO_4$	HgS	0.78424	9.89445

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS
(Continued)

Weighed	Sought	Factor	Logarithm
Molybdenum: Mo = 96.			−10
Mo	MoO_3	1.5000	10.17609
	MoS_3	2.0019	10.30144
	$PbMoO_4$	3.8239	10.58251
MoO_3	Mo	0.66667	9.82391
	MoS_3	1.3346	10.12535
	$(NH_4)_2MoO_4$	1.3617	10.13408
	$(NH_4)_3PO_4 \cdot 12MoO_3$	1.0863	10.03596
MoS_3	Mo	0.49953	9.69856
	MoO_3	0.74930	9.87466
	$(NH_4)_2MoO_4$	1.0201	10.00864
$(NH_4)_2MoO_4$	MoO_3	0.73437	9.86592
	MoS_3	0.9803	9.99136
	$(NH_4)_3PO_4 \cdot 12MoO_3$	0.79778	9.90188
$(NH_4)_3PO_4 \cdot 12MoO_3$	MoO_3	0.92053	9.96404
	$(NH_4)_2MoO_4$	1.2535	10.09812
$PbMoO_4$	Mo	0.26144	9.41737
	MoO_3	0.39216	9.59346
	$(NH_4)_2MoO_4$	0.53399	9.72753
Nickel: Ni = 58.68			
Ni	Ni, glyoxime	0.2031	9.30771
	$Ni(NO_3)_2 \cdot 6H_2O$	4.9556	10.69510
	NiO	1.2726	10.10471
	$NiSO_4$	2.6370	10.42111
	$NiSO_4 \cdot 7H_2O$	4.7861	10.67998
Ni, glyoxime	Ni	4.9236	10.69228
$Ni(NO_3)_2 \cdot 6H_2O$	Ni	0.20179	9.30490
	NiO	0.25681	9.40961
	$NiSO_4$	0.53212	9.72601
NiO	Ni	0.78576	9.89529
	$Ni(NO_3)_2 \cdot 6H_2O$	3.8939	10.59039
	$NiSO_4$	2.0720	10.31639
	$NiSO_4 \cdot 7H_2O$	3.7607	10.57527
$NiSO_4$	Ni	0.37922	9.57889
	$Ni(NO_3)_2 \cdot 6H_2O$	1.8793	10.27400
	NiO	0.48262	9.68361
	$NiSO_4 \cdot 7H_2O$	1.81149	10.25886

Weighed	Sought	Factor	Logarithm
Nickel:			−10
$NiSO_4 \cdot 7H_2O$	Ni	0.20894	9.32011
	NiO	0.26591	9.42494
	$NiSO_4$	0.55097	9.74113
Nitrogen: N = 14.01			
$AgNO_2$	HNO_2	0.30554	9.48507
	N_2O_3	0.24699	9.39269
HNO_2	$AgNO_2$	3.2729	10.51493
HNO_3	N	0.22231	9.34696
	NH_3	0.27023	9.43173
	NH_4Cl	0.84893	9.92887
	$(NH_4)_2PtCl_6$	3.5230	10.54691
	Pt	1.5480	10.18997
	SO_3	0.63520	9.80291
KNO_3	N_2O_5	0.53417	9.72768
N	HNO_3	4.4982	10.65304
	$NaNO_3$	6.0678	10.78303
	NH_3	1.2155	10.08477
	NH_4Cl	3.8187	10.58191
	$(NH_4)_2PtCl_6$	15.8469	11.19995
	$(NH_4)_2SO_4$	4.7156	10.67354
	NO_2	3.2841	10.51641
	N_2O_3	2.7131	10.43346
	NO_3	4.4261	10.64602
	N_2O_5	3.8551	10.58603
	Pt	6.9665	10.84301
	SO_3	2.8572	10.45594
$NaNO_3$	N	0.16481	9.21697
	N_2O_5	0.63533	9.80300
N_2O_3	$AgNO_2$	4.0487	10.60731
	N	0.36858	9.56654
N_2O_5	KNO_3	1.8721	10.27232
	N	0.25940	9.41397
	$NaNO_3$	1.5740	10.19700
	NH_3	0.31531	9.49874
	$(NH_4)_2PtCl_6$	4.1101	10.61392
	$(NH_4)_2SO_4$	1.2232	10.08750
	Pt	1.8071	10.25698
	SO_3	0.74116	9.86991
NO_2	N	0.30450	9.48359
NO_3	N	0.22593	9.35398
NH_3	HNO_3	3.7006	10.56827
	N	0.82268	9.91523
	N_2O_5	3.1714	10.50126
NH_4Cl	HNO_3	1.1780	10.07113
	N	0.26187	9.41809
$(NH_4)_2PtCl_6$	HNO_3	0.28380	9.45301
	N	0.06310	8.80005
	N_2O_5	0.24327	9.38609
$(NH_4)_2SO_4$	N	0.21206	9.32646
	N_2O_5	0.81753	9.91250
Pt	HNO_3	0.64570	9.81003
	N	0.14345	9.15699
	N_2O_5	0.55338	9.74302
SO_3	HNO_3	1.5741	10.19703

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS
(Continued)

Weighed	Sought	Factor	Logarithm
Nitrogen:			−10
SO_3	N	0.34999	9.54406
	N_2O_5	1.3492	10.13008
Phosphorus: P = 31.04			
$AgPO_4$	P	0.07414	8.87004
	PO_4	0.22700	9.35603
	P_2O_5	0.16968	9.22963
$Ag_4P_2O_7$	P	0.10251	9.01077
	PO_4	0.31388	9.49676
	P_2O_5	0.23461	9.37035
Al_2O_3	P_2O_5	1.3890	10.14308
$AlPO_4$	PO_4	0.77830	9.89115
	P_2O_5	0.58175	9.76474
$Ca_3(PO_4)_2$	P_2O_5	0.45787	9.66075
$FePO_4$	PO_4	0.62991	9.79928
	P_2O_5	0.47080	9.67289
$Mg_2P_2O_7$	Na_2HPO_4	1.2756	10.10571
	$Na_2HPO_4 \cdot 12H_2O$	3.2164	10.50744
	$NaNH_4HPO_4 \cdot 4H_2O$	1.8771	10.27373
	P	0.27861	9.44511
	PO_4	0.85384	9.93138
	P_2O_5	0.63852	9.80517
Na_2HPO_4	$Mg_2P_2O_7$	0.78395	9.89429
	P_2O_5	0.50010	9.69906
$Na_2HPO_4 \cdot 12H_2O$	$Mg_2P_2O_7$	0.31006	9.49256
	P_2O_5	0.19830	9.29733
$NaNH_4HPO_4 \cdot 4H_2O$	$Mg_2P_2O_7$	0.53244	9.72627
	P_2O_5	0.33966	9.53104
$(NH_4)_3PO_4 \cdot 12MoO_3$	P	0.01653	8.21842
	PO_4	0.05063	8.70441
	P_2O_5	0.03784	8.57800
P	Ag_3PO_4	13.4884	11.12996
	$Ag_4P_2O_7$	9.7550	10.98923
	$Mg_2P_2O_7$	3.5877	10.55481
	$(NH_4)_3PO_4 \cdot 12MoO_3$	60.4755	11.78158
	P_2O_5	2.2886	10.35958
	$U_2P_2O_{11}$	11.5090	11.06104
PO_4	$AgPO_4$	4.4052	10.64397
	$Ag_4P_2O_7$	3.1860	10.50324
	$AlPO_4$	1.2845	10.10885
	$FePO_4$	1.5875	10.20072
	$Mg_2P_2O_7$	1.1712	10.06862
	$(NH_4)_3PO_4 \cdot 12MoO_3$	19.7591	11.29559
	$U_2P_2O_{11}$	3.7588	10.57505
P_2O_5	Ag_3PO_4	5.8935	10.77038
	$Ag_4P_2O_7$	4.2623	10.62965
	Al_2O_3	0.71933	9.85692

Weighed	Sought	Factor	Logarithm
Phosphorus:			−10
P_2O_5	$AlPO_4$	1.7190	10.23526
	$FePO_4$	2.1238	10.32711
	$Mg_2P_2O_7$	1.5662	10.19483
	Na_2HPO_4	1.9996	10.30094
	$Na_2HPO_4 \cdot 12H_2O$	5.0428	10.70267
	$NaNH_4HPO_4 \cdot 4H_2O$	2.9441	10.46896
	$(NH_4)_3PO_4 \cdot 12MoO_3$	26.4243	11.42200
	$U_2P_2O_{11}$	5.0287	10.70146
$U_2P_2O_{11}$	P	0.08689	8.93897
	PO_4	0.26604	9.42495
	P_2O_5	0.19886	9.29855
Platinum: Pt = 195.2			
$H_2PtCl_6 \cdot 6H_2O$	K_2PtCl_6	0.93844	9.97239
K_2PtCl_6	$H_2PtCl_6 \cdot 6H_2O$	1.0656	10.02761
	Pt	0.40151	9.60370
	$PtCl_4$	0.69326	9.84090
	$PtCl_4 \cdot 5H_2O$	0.87856	9.94377
$(NH_4)_2PtCl_6$	Pt	0.43960	9.64306
	$PtCl_4$	0.75904	9.88026
	$PtCl_6$	0.91876	9.96320
Pt	$H_2PtCl_6 \cdot 6H_2O$	2.6558	10.42419
	K_2PtCl_6	2.4906	10.39630
	$(NH_4)_2PtCl_6$	2.2748	10.35694
	$PtCl_4$	1.7266	10.23720
	$PtCl_4 \cdot 5H_2O$	2.1881	10.34007
$PtCl_4$	K_2PtCl_6	1.4424	10.15910
	$(NH_4)_2PtCl_6$	1.3175	10.11974
	Pt	0.57917	9.76280
$PtCl_6$	$(NH_4)_2PtCl_6$	1.0884	10.03680
$PtCl_4 \cdot 5H_2O$	K_2PtCl_6	1.1382	10.05623
	Pt	0.45701	9.65993
Potassium: K = 39.1			
Ag	KBr	1.1033	10.04268
	KCl	0.69114	9.83957
	$KClO_3$	1.1361	10.05541
	$KClO_4$	1.2844	10.10870
	KCN	0.60354	9.78071
	KI	1.5390	10.18722
AgBr	KBr	0.63375	9.80192
	$KBrO_3$	0.88934	9.94907
AgCl	KCl	0.52017	9.71614
	$KClO_3$	0.85503	9.93198
	$KClO_4$	0.96666	9.98527
AgCN	KCN	0.48630	9.68690
AgI	KI	0.70707	9.84946
	KIO_3	0.91148	9.95975

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS
(Continued)

Weighed	Sought	Factor	Logarithm
Potassium:			−10
$BaCrO_4$	K_2CrO_4	0.76650	9.88451
	$K_2Cr_2O_7$	0.58019	9.76357
$BaSO_4$	$KHSO_4$	0.58334	9.76592
	K_2S	0.47235	9.67426
	K_2SO_4	0.74652	9.87304
Br	K	0.48924	9.68952
	KBr	1.4892	10.17296
CaF_2	$KF \cdot 2H_2O$	2.4108	10.38216
$CaSO_4$	$KF \cdot 2H_2O$	1.3829	10.14079
Cl	K	1.1027	10.04244
	KCl	2.1026	10.32277
	$KClO_3$	3.4563	10.53861
	$KClO_4$	3.9075	10.59190
	K_2O	1.3282	10.12328
CO_2	K_2O	2.1407	10.33056
	K_2CO_3	3.1407	10.49703
I	KI	1.3081	10.11663
	KIO_3	1.6863	10.22692
K	Br	2.0440	10.31048
	Cl	0.90691	9.95756
	KBr	3.0440	10.48355
	KCl	1.9069	10.28033
	KI	4.2460	10.62798
	K_2O	1.2046	10.08084
	KNO_3	2.5859	10.41261
	K_2PtCl_6	6.2169	10.79357
	K_2SO_4	2.2284	10.34799
	Pt	2.4961	10.39727
K_3AsO_4	$Mg_2As_2O_7$	0.60596	9.78244
KBr	Ag	0.90640	9.95732
	AgBr	1.5779	10.19808
	Br	0.67149	9.82704
	K	0.32852	9.51656
	K_2O	0.39573	9.59740
$KBrO_3$	AgBr	1.1244	10.05093
KCl	Ag	1.4469	10.16043
	AgCl	1.9225	10.28386
	Cl	0.47558	9.67723
	K	0.52440	9.71967
	K_2CO_3	0.92677	9.96697
	$K_2Cr_2O_7$	1.9705	10.29480
	$KHCO_3$	1.3427	10.12796
	KNO_3	1.3560	10.13228
	K_2O	0.63169	9.80051
	K_2PtCl_6	3.2602	10.51324
	K_2SO_4	1.1685	10.06763
	Pt	1.3090	10.11694
$KClO_3$	Ag	0.88022	9.94459
	AgCl	1.1696	10.06802
	Cl	0.28933	9.46139
$KClO_4$	Ag	0.77857	9.89130
	AgCl	1.0345	10.01473
	Cl	0.25592	9.40810
KCN	AgCN	2.0564	10.31310
K_2CO_3	CO_2	0.31840	9.50297
	KCl	1.0790	10.03303
	KOH	0.81201	9.90956
	K_2O	0.68161	9.83354

Weighed	Sought	Factor	Logarithm
Potassium:			−10
K_2CO_3	K_2PtCl_6	3.5178	10.54627
	K_2SO_4	1.2609	10.10068
K_2CrO_4	$BaCrO_4$	1.3045	10.11549
$K_2Cr_2O_7$	$BaCrO_4$	1.7236	10.23643
	KCl	0.50699	9.70500
	K_2O	0.32019	9.50541
$KF \cdot 2H_2O$	CaF_2	0.41480	9.61784
	$CaSO_4$	0.72310	9.85920
$KHAsO_4$	$Mg_2As_2O_7$	0.71173	9.85232
$KHCO_3$	KCl	0.74480	9.87204
	K_2O	0.94098	9.97358
	K_2PtCl_6	4.8563	10.68631
	K_2SO_4	0.87034	9.93969
$KHSO_4$	$BaSO_4$	1.7143	10.23409
	K_2SO_4	0.63986	9.80609
KI	Ag	0.64981	9.81278
	AgI	1.4143	10.15054
	I	0.76448	9.88337
	K	0.23551	9.37202
	K_2O	0.28370	9.45286
KIO_3	AgI	1.0971	10.04025
	I	0.59304	9.77308
K_2MnO_4	Mn_2O_3	0.38686	9.58756
	MnS	0.44128	9.64471
$KMnO_4$	Mn_2O_3	0.48259	9.68358
	MnS	0.55047	9.74073
KNO_2	K_2SO_4	1.0237	10.01017
	N_2O_3	0.44660	9.64992
KNO_3	K	0.38671	9.58739
	KCl	0.73742	9.86772
	K_2O	0.46583	9.66823
	K_2PtCl_6	2.4042	10.38096
	N	0.13857	9.14165
	NH_3	0.16843	9.22642
	NO	0.29681	9.47248
	N_2O_5	0.53417	9.72768
K_2O	Cl	0.75287	9.87672
	CO_2	0.46714	9.66945
	K	0.83015	9.91916
	KBr	2.5270	10.40260
	KCl	1.5830	10.19949
	K_2CO_3	1.4671	10.16646
	$K_2Cr_2O_7$	3.1231	10.49459
	$KHCO_3$	1.0627	10.02642
	KI	3.5248	10.54714
	KOH	1.1913	10.07602
	KNO_3	2.14660	10.33177
	K_2PtCl_6	5.1610	10.71273
	K_2SO_4	1.8499	10.26715
	N_2O_5	1.1467	10.05945
KOH	K_2CO_3	1.2315	10.09044
	K_2O	0.83942	9.92398
K_2PtCl_6	K_2CO_3	0.28427	9.45373
	KCl	0.30674	9.48676
	$KHCO_3$	0.20591	9.31369
	KNO_3	0.41595	9.61904
	K_2O	0.19376	9.28727
	K_2SO_4	0.35844	9.55442

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS (Continued)

Weighed	Sought	Factor	Logarithm
Potassium:			−10
K_2PtCl_6..	$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$.....	1.9521	10.29050
	$K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O$.....	2.0545	10.31269
K_2S.....	$BaSO_4$.....	2.1171	10.32574
	K_2SO_4.....	1.5804	10.19877
K_2SiO_3...	SiO_2.......	0.39029	9.59139
K_2SO_4...	$BaSO_4$.....	1.3396	10.12698
	KCl.......	0.85573	9.93234
	K_2CO_3.....	0.79307	9.89931
	$KHCO_3$....	1.1490	10.06032
	$KHSO_4$....	1.5628	10.19390
	KNO_2......	0.97682	9.98981
	KNO_3.....	1.1604	10.06461
	K_2O.......	0.54057	9.73285
	K_2PtCl_6....	2.7899	10.44559
	K_2S........	0.63273	9.80122
	SO_3........	0.45943	9.66222
$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$	K_2PtCl_6....	0.51228	9.70951
$K_2SO_4 \cdot Cr_2(SO_4)_3$ $24H_2O$...	K_2PtCl_6....	0.48673	9.68729
$Mg_2As_2O_7$	K_3AsO_4....	1.6503	10.21756
	K_2HAsO_4...	1.4050	10.14768
Mn_2O_3...	K_2MnO_4...	2.5848	10.41244
	$KMnO_4$....	2.0721	10.31642
MnS.....	K_2MnO_4....	2.2661	10.35528
	$KMnO_4$....	1.8166	10.25926
N.......	KNO_3.....	7.2169	10.85835
NH_3.....	KNO_3......	5.9372	10.77358
NO......	KNO_3......	3.3692	10.52752
N_2O_3.....	KNO_2......	2.2391	10.35008
N_2O_5.....	K_2O.......	0.87207	9.94055
	KNO_3......	1.8721	10.27232
Pt.......	K.........	0.40062	9.60273
	KCl.......	0.76394	9.88306
SiO_2.....	K_2SiO_3.....	2.5622	10.40861
SO_3......	K_2SO_4......	2.1766	10.33778
Silicon: Si = 28.3			
$BaSiF_6$...	SiF_4.......	0.37294	9.57163
	SiO_2.......	0.21561	9.33367
H_2SiO_3...	SiO_2.......	0.76993	9.88645
K_2SiF_6...	SiF_4.......	0.47301	9.67487
	SiO_2.......	0.27347	9.43691
Si.......	SiO_2.......	2.1307	10.32853
SiF_4.....	$BaSiF_6$.....	2.6814	10.42837
	K_2SiF_6.....	2.1141	10.32513
	SiO_2.......	0.57815	9.76204
SiO_2.....	$BaSiF_6$.....	4.6380	10.66633
	H_2SiO_3.....	1.2988	10.11355
	K_2SiF_6.....	3.6567	10.56309
	Si.........	0.46933	9.67147
	SiF_4.......	1.7296	10.23796

Weighed	Sought	Factor	Logarithm
Silicon:			−10
SiO_2.....	SiO_3.......	1.2653	10.10220
	SiO_4.......	1.5307	10.18488
	Si_2O.......	1.3980	10.14551
	$Si(OH)_4$....	1.5975	10.20344
SiO_3.....	SiO_2.......	0.79031	9.89780
SiO_4.....	SiO_2.......	0.65331	9.81512
Si_2O.....	SiO_2.......	0.71530	9.85449
$Si(OH)_4$.	SiO_2.......	0.62598	9.79656
Silver: Ag = 107.88			
Ag......	AgBr......	1.7408	10.24076
	AgCl......	1.3287	10.12343
	AgCN.....	1.2411	10.09381
	AgI.......	2.1765	10.33776
	$AgNO_3$.....	1.5748	10.19723
	Ag_2O......	1.0742	10.03107
	Ag_3PO_4....	1.2932	10.11182
	$Ag_4P_2O_7$....	1.4034	10.14719
	Br.........	0.74083	9.86972
	Cl.........	0.32870	9.51680
	I..........	1.1765	10.07059
AgBr....	Ag........	0.57443	9.75924
	Br.........	0.42556	9.62896
AgCl....	Ag........	0.75261	9.87657
	$AgNO_3$.....	1.1852	10.07380
	Ag_2O......	0.80842	9.90764
	Cl.........	0.24738	9.39337
AgCN...	Ag.........	0.80573	9.90619
AgI.....	Ag........	0.45945	9.66224
	I..........	0.54055	9.73283
Ag_2O....	Ag........	0.93095	9.96893
	AgCl......	1.2370	10.09236
Ag_3PO_4..	Ag........	0.77317	9.88828
$Ag_4P_2O_7$.	Ag........	0.71253	9.85281
Br......	Ag........	1.3498	10.13028
	AgBr......	2.3498	10.37104
Cl.......	Ag........	3.0423	10.48320
	AgCl......	4.0423	10.60663
I........	Ag........	0.84998	9.92941
	AgI........	1.8500	10.26717
Sodium: Na = 23			
Ag......	NaBr......	0.95622	9.98056
	NaCl......	0.54190	9.73392
	NaI.......	1.3897	10.14292
AgBr....	NaBr......	0.54802	9.73880
AgCl....	NaCl......	0.40784	9.61049
AgI.....	NaI.......	0.63850	9.80516
$BaSO_4$...	$NaHSO_4$...	0.51437	9.71128
	$NaHSO_4 \cdot H_2O$.....	0.59153	9.77198
	Na_2S......	0.33440	9.52427
	Na_2SO_3....	0.54003	9.73242
	$Na_2SO_3 \cdot 7H_2O$.....	1.0803	10.03354
	Na_2SO_4....	0.60858	9.78432
	$Na_2SO_4 \cdot 10H_2O$....	1.3804	10.14001

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS (Continued)

Weighed	Sought	Factor	Logarithm
Sodium:			−10
B_2O_3	$Na_2B_4O_7$	1.4429	10.15922
	$Na_2B_4O_7 \cdot 10H_2O$	2.7297	10.43612
Br	Na	0.28779	9.45907
	NaBr	1.2878	10.10984
	Na_2O	0.38788	9.58870
$CaCl_2$	NaCl	1.0534	10.02259
$CaCO_3$	Na_2CO_3	1.0590	10.02492
CaF_2	NaF	1.0757	10.03168
CaO	Na_2CO_3	1.8898	10.27642
$CaSO_4$	Na_2CO_3	0.77867	9.89135
Cl	Na	0.64862	9.81199
	NaCl	1.6486	10.21712
	Na_2O	0.87422	9.94162
CO_2	Na_2CO_3	2.4089	10.38182
	Na_2O	1.4089	10.14888
H_3BO_3	$Na_2B_4O_7$	0.81420	9.91073
	$Na_2B_4O_7 \cdot 10H_2O$	1.5404	10.18763
I	Na	0.18122	9.25820
	NaI	1.1812	10.07233
	Na_2O	0.24425	9.38783
KBF_4	$Na_2B_4O_7$	0.40047	9.60257
	$Na_2B_4O_7 \cdot 10H_2O$	0.75765	9.87947
$Mg_2As_2O_7$	Na_2HAsO_3	1.0947	10.39300
	Na_2HAsO_4	1.1978	10.07837
$MgCl_2$	NaCl	1.2276	10.08906
$Mg_2P_2O_7$	Na_2HPO_4	1.2756	10.10571
	$Na_2HPO_4 \cdot 12H_2O$	3.2169	10.50744
	$NaNH_4HPO_4 \cdot 4H_2O$	1.8781	10.27373
	$Na_4P_2O_7 \cdot 10H_2O$	2.0036	10.30181
Na	Br	3.4748	10.54093
	Cl	1.5417	10.18801
	I	5.5182	10.74180
	NaBr	4.4747	10.65077
	NaCl	2.5418	10.40514
	Na_2CO_3	2.3044	10.36255
	$NaHCO_3$	3.6525	10.56259
	NaI	6.5183	10.81413
	Na_2O	1.3478	10.12963
	Na_2SO_4	3.0883	10.48972
$Na_2B_4O_7$	B_2O_3	0.69308	9.84078
	H_3BO_3	1.2282	10.08927
	KBF_4	2.4971	10.39743
$Na_2B_4O_7 \cdot 10H_2O$	B_2O_3	0.36634	9.56388
	H_3BO_3	0.64918	9.81237
	KBF_4	1.3199	10.12053
NaBr	Ag	1.0458	10.01944
	AgBr	1.8247	10.26120
	Br	0.77654	9.89016
	Na	0.22348	9.34923
	Na_2O	0.30120	9.47886
NaCl	Ag	1.8453	10.26608

Weighed	Sought	Factor	Logarithm
Sodium:			−10
NaCl	AgCl	2.4520	10.38951
	Cl	0.60657	9.78288
	Na	0.39343	9.59487
	Na_2CO_3	0.90661	9.95742
	$NaHCO_3$	1.4370	10.15746
	Na_2HPO_4	1.2150	10.08456
	Na_2O	0.53028	9.72451
	Na_2SO_4	1.2150	10.08458
Na_2CO_3	$CaCO_3$	0.94423	9.97508
	CaO	0.52915	9.72358
	$CaSO_4$	1.2842	10.10863
	CO_2	0.41509	9.61814
	Na	0.43396	9.63745
	NaCl	1.1030	10.04258
	$NaHCO_3$	1.5850	10.20003
	Na_2O	0.58490	9.76708
	NaOH	0.75486	9.87787
	Na_2SO_4	1.3402	10.12717
$Na_2CO_3 \cdot 10H_2O$	Na_2SO_4	0.49643	9.69585
NaF	CaF_2	0.92965	9.96832
Na_2HAsO_3	$Mg_2As_2O_7$	0.91348	9.96070
Na_2HAsO_4	$Mg_2As_2O_7$	0.83490	9.92163
$NaHCO_3$	Na	0.27379	9.43741
	NaCl	0.69589	9.84254
	Na_2CO_3	0.63090	9.79996
	Na_2O	0.36901	9.56704
$NaNH_4HPO_4 \cdot 4H_2O$	$Mg_2P_2O_7$	0.53244	9.72627
	NH_3	0.08144	8.91084
	P_2O_5	0.33966	9.53104
Na_2HPO_4	$Mg_2P_2O_7$	0.78395	9.89429
	Na_2O	0.43646	9.63995
	$Na_4P_2O_7$	0.93656	9.97154
	P_2O_5	0.50010	9.69906
$Na_2HPO_4 \cdot 12H_2O$	$Mg_2P_2O_7$	0.31086	9.49256
	$Na_4P_2O_7$	0.37139	9.56981
	P_2O_5	0.19830	9.29733
$NaHSO_3$	SO_2	0.61555	9.78926
$NaHSO_4$	$BaSO_4$	1.9441	10.28872
$NaHSO_4 \cdot H_2O$	$BaSO_4$	1.6905	10.22802
NaI	Ag	0.71958	9.85708
	AgI	1.5661	10.19484
	I	0.84659	9.92767
	Na	0.15341	9.18587
	Na_2O	0.20678	9.31550
$NaNO_3$	Na_2O	0.36467	9.56189
	N	0.16481	9.21697
	NH_3	0.20038	9.30185
	NO	0.35302	9.54780
	N_2O_5	0.63533	9.80300
Na_2O	Br	2.5781	10.41130
	Cl	1.1439	10.05838

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS (Continued)

Weighed	Sought	Factor	Logarithm
Sodium:			−10
Na_2O	CO_2	0.70968	9.85106
	I	4.0942	10.61217
	Na	0.74194	9.87037
	NaBr	3.3200	10.52114
	NaCl	1.8858	10.27549
	Na_2CO_3	1.7097	10.23292
	NaI	4.8350	10.68440
	Na_2HPO_4	2.2911	10.36005
	NaOH	1.2906	10.11079
	Na_2SO_4	2.2913	10.36008
	N_2O_5	1.7422	10.24111
	SO_3	1.2913	10.11103
NaOH	Na_2CO_3	1.3247	10.12213
	Na_2O	0.77484	9.88921
$Na_4P_2O_7 \cdot 10H_2O$	$Mg_2P_2O_7$	0.49911	9.69820
Na_2S	$BaSO_4$	2.9904	10.47573
Na_2SO_3	$BaSO_4$	1.8517	10.26757
	SO_2	0.50817	9.70601
$Na_2SO_3 \cdot 7H_2O$	$BaSO_4$	0.92569	9.96647
	SO_2	0.25403	9.40489
Na_2SO_4	$BaSO_4$	1.6432	10.21569
	Na	0.32381	9.51029
	NaCl	0.82303	9.91542
	Na_2CO_3	0.74616	9.87283
	$Na_2CO_3 \cdot 10H_2O$	2.0144	10.30415
	Na_2O	0.43644	9.63992
	SO_3	0.56356	9.75094
$Na_2SO_4 \cdot 10H_2O$	$BaSO_4$	0.72444	9.86000
N	$NaNO_3$	6.0678	10.78303
NH_3	$NaNO_3$	4.9918	10.69826
	$NaNH_4HPO_4 \cdot 4H_2O$	12.2790	11.08416
NO	$NaNO_3$	2.8327	10.45220
N_2O_5	$NaNO_3$	1.5740	10.19700
	Na_2O	0.57397	9.75889
P_2O_5	Na_2HPO_4	1.9996	10.30094
	$Na_2HPO_4 \cdot 12H_2O$	5.0428	10.70267
	$NaNH_4HPO_4 \cdot 4H_2O$	2.9441	10.46896
SO_2	$NaHSO_3$	1.6246	10.21075
	Na_2SO_3	1.9678	10.29398
	$Na_2SO_3 \cdot 7H_2O$	3.9365	10.59511
SO_3	Na_2O	0.77442	9.88898
	Na_2SO_4	1.7744	10.24905
Strontium: Sr = 87.63			
CO_2	$SrCO_3$	3.3550	10.52569
SO_3	SrO	1.2994	10.11207
	$SrSO_4$	2.2944	10.36067
Sr	$SrCO_3$	1.6847	10.22652
	SrO	1.1827	10.07285
Strontium			−10
Sr	$SrSO_4$	2.0962	10.32142
$SrCl_2$	$SrCO_3$	0.93110	9.96900
	SrO	0.65363	9.81533
	$SrSO_4$	1.1586	10.06393
$SrCO_3$	CO_2	0.29804	9.47428
	Sr	0.59358	9.77348
	$SrCl_2$	1.0740	10.03100
	$Sr(HCO_3)_2$	1.4201	10.15232
	$Sr(NO_3)_2$	1.4337	10.15645
	SrO	0.70198	9.84633
	$SrSO_4$	1.2443	10.09493
$Sr(HCO_3)_2$	$SrCO_3$	0.70417	9.84768
	SrO	0.49432	9.69401
$Sr(NO_3)_2$	$SrCO_3$	0.69751	9.84355
	$SrSO_4$	0.86790	9.93847
SrO	SO_3	0.77256	9.88793
	Sr	0.84558	9.92715
	$SrCl_2$	1.5299	10.18467
	$SrCO_3$	1.42453	10.15367
	$Sr(HCO_3)_2$	2.0228	10.30599
$SrSO_4$	SO_3	0.43584	9.63933
	Sr	0.47705	9.67856
	$SrCl_2$	0.86314	9.93608
	$SrCO_3$	0.80369	9.90509
	$Sr(NO_3)_2$	1.1522	10.06153
	SrO	0.56416	9.75140
Sulphur: S = 32.06			
As_2S_3	H_2S	0.41539	9.61846
	S	0.39053	9.59165
$BaSO_4$	H_2S	0.14598	9.16429
	H_2SO_3	0.35161	9.54606
	H_2SO_4	0.42015	9.62340
	S	0.13734	9.13780
	SO_2	0.27443	9.43843
	SO_3	0.34297	9.53526
	SO_4	0.41152	9.61439
CdS	H_2S	0.23589	9.37271
	S	0.22193	9.34622
H_2S	As_2S_3	2.4074	10.38155
	$BaSO_4$	6.8503	10.83571
	CdS	4.2393	10.62729
	SO_3	2.3495	10.37098
H_2SO_3	$BaSO_4$	2.8441	10.45394
H_2SO_4	$BaSO_4$	2.3801	10.37660
	$(NH_4)_2SO_4$	1.3472	10.12943
	SO_3	0.81631	9.91186
$(NH_4)_2SO_4$	SO_3	0.60592	9.78242
	H_2SO_4	0.74227	9.87056
S	As_2S_3	2.5587	10.40802
	$BaSO_4$	7.2810	10.86219
	CdS	4.5059	10.65378
SO_2	$BaSO_4$	3.6439	10.56157
SO_3	$BaSO_4$	2.9157	10.46474
SO_4	$BaSO_4$	2.4300	10.38560

GRAVIMETRIC FACTORS AND THEIR LOGARITHMS
(Continued)

Weighed	Sought	Factor	Logarithm
Tin:			
Sn = 118.7			−10
Sn	$SnCl_2$	1.5975	10.20344
	$SnCl_2 \cdot 2H_2O$	1.9010	10.27898
	$SnCl_4$	2.1949	10.34141
	$SnCl_4(NH_4Cl)_2$	3.0964	10.49086
	SnO	1.1348	10.05492
	SnO_2	1.2696	10.10367
$SnCl_2$	Sn	0.62599	9.79657
	SnO_2	0.79475	9.90023
$SnCl_2 \cdot 2H_2O$	Sn	0.52609	9.72102
	SnO_2	0.66785	9.82468
$SnCl_4$	Sn	0.45559	9.65857
	SnO_2	0.57841	9.76224
$SnCl_4(NH_4Cl)_2$	Sn	0.32296	9.50915
	SnO_2	0.41002	9.61281
SnO	Sn	0.88122	9.94508
	SnO_2	1.1188	10.04875
SnO_2	Sn	0.78766	9.89634
	$SnCl_2$	1.2583	10.09975
	$SnCl_2 \cdot 2H_2O$	1.4973	10.17531
	$SnCl_4$	1.7289	10.23777
	$SnCl_4(NH_4Cl)_2$	2.4389	10.38719
	SnO	0.89383	9.95125
Titanium:			
Ti = 48.1			
Ti	TiO_2	1.6652	10.22148
TiO_2	Ti	0.60051	9.77852
Tungsten:			
W = 184			
W	WO_2	1.1739	10.06963
	WO_3	1.2609	10.10067
WO_2	W	0.85187	9.93037
WO_3	W	0.79310	9.89933
Uranium:			
U = 238.2			
U	UO_2	1.1343	10.05473
	U_3O_8	1.1791	10.07155
	$U_2P_2O_{11}$	1.4997	10.17600
UO_2	U	0.88157	9.94526

Weighed	Sought	Factor	Logarithm
Uranium:			−10
UO_2	U_3O_8	1.0395	10.01682
	$U_2P_2O_{11}$	1.3221	10.12126
U_3O_8	U	0.84809	9.92844
	UO_2	0.96202	9.98318
	$UO_2(NO_3)_2 \cdot 6H_2O$	1.7885	10.25249
$UO_2(NO_3)_2 \cdot 6H_2O$	U_3O_8	0.55914	9.74752
$U_2P_2O_{11}$	U	0.67624	9.83010
	UO_2	0.76709	9.88485
Vanadium:			
V = 51			
V	V_2O_5	1.7843	10.25147
VO_4	V_2O_5	0.79130	9.89834
V_2O_5	V	0.56045	9.74853
	VO_4	1.2638	10.10166
Zinc:			
Zn = 65.37			
$BaSO_4$	$ZnSO_4 \cdot 7H_2O$	1.2318	10.09054
Zn	ZnO	1.2447	10.09508
	$Zn_2P_2O_7$	2.3315	10.36763
	ZnS	1.4904	10.17330
$ZnCl_2$	ZnO	0.59702	9.77599
$ZnCO_3$	ZnO	0.64903	9.81227
ZnO	Zn	0.80338	9.90492
	$ZnCl_2$	1.6749	10.22401
	$ZnCO_3$	1.5407	10.18773
	$Zn_2P_2O_7$	1.8773	10.27254
	ZnS	1.1974	10.07825
$Zn_2P_2O_7$	Zn	0.42891	9.63237
	ZnO	0.53390	9.72746
ZnS	$BaSO_4$	2.3959	10.37947
	Zn	0.67094	9.82668
	ZnO	0.83516	9.92177
	$ZnSO_4 \cdot 7H_2O$	2.9506	10.46991
$ZnSO_4 \cdot 7H_2O$	$BaSO_4$	0.81182	9.90946
	ZnO	0.28299	9.45177
	ZnS	0.33884	9.52999

HEAT OF FORMATION

(From Thomsen's Thermochemistry, Longmans, Green and Co., publishers, by permission)

The following tables give the heats of formation of various compounds, chlorides, oxides and hydroxides and sulphides. The values are given in small calories and for a temperature of about 18° C. for substances in their normal state at that temperature.

Chlorides

Reaction	Heat of formation of the compound	Heat of solution of the compound	Heat of formation in aqueous solution
(K_2, Cl_2)	211220.	− 8880.	202340.
(Na_2, Cl_2)	195380.	− 2360.	163020.
(Li_2, Cl_2)	187620.	+ 16880.	204500.
(Ba, Cl_2)	x + 48240.	+ 2070.	x + 50310.
(Ba, Cl_2, $2H_2O$)	x + 55240.	− 4930.	
(Sr, Cl_2)	184560.	+ 11140.	195690.
(Sr, Cl_2, $6H_2O$)	203190.	− 7500.	
(Ca, Cl_2)	183890.	+ 17410.	201300.
(Ca, Cl_2, $6H_2O$)	205640.	− 4340.	
(Mg, Cl_2)	151010.	+ 35920.	186930.
(Mg, Cl_2, $6H_2O$)	183980.	+ 2950.	
(Al_2Cl_6)	321960.	+ 153690.	475650.
(Mn, Cl_2)	111990.	+ 16010.	128000.
(Mn, Cl_2, $4H_2O$)	126460.	+ 1540.	
(Zn, Cl_2)	97210.	+ 15630.	112840.
(Cd, Cl_2)	93240.	+ 3010.	96250.
(Cd, Cl_2, $2H_2O$)	98530.	− 2280.	
(Fe, Cl_2)	82050.	+ 17900.	99950.
(Fe, Cl_2, $4H_2O$)	97200.	+ 2750.	
(Fe_2, Cl_6)	192080.	+ 63360.	255440.
(Co, Cl_2)	76480.	+ 18340.	94820.
(Co, Cl_2, $6H_2O$)	97670.	− 2850.	
(Ni, Cl_2)	74530.	+ 19170.	97300.
(Ni, Cl_2, $6H_2O$)	94860.	− 1160.	
(Cu_2, Cl_2)	65750.	....	....
(Cu, Cl_2)	51630.	+ 11080.	62710.
(Cu, Cl_2, $2H_2O$)	58500.	+ 4210.	
(Pb, Cl_2)	82770.	− 6800.	75970.
(Hg_2, Cl_2)	65210.	....	....
(Hg, Cl_2)	54490.	− 3300.	51190.
(Hg, Cl_2, 2KCl, H_2O)	60620.	− 16390.	44230.
(Tl_2, Cl_2)	97160.	− 20200.	76900.
(Ag_2, Cl_2)	58760.	....	....

HEAT OF FORMATION (Continued)

Chlorides (Continued)

Reaction	Heat of formation of the compound	Heat of solution of the compound	Heat of formation in aqueous solution
(Au_2, Cl_2)	11620.	....	....
(Au, Cl_3)	22820.	+ 4450.	27270.
$(Au, Cl_3, 2H_2O)$	28960.	− 1690.	
$(Au, Cl_4, H, 4H_2O)$	76950.	− 5830.	71120.
(Sn, Cl_2)	80790.	+ 350.	81140.
$(Sn, Cl_2, 2H_2O)$	86560.	− 5370.	
$(Sn, Cl_2, 2KCl, H_2O)$	85680.	− 13420.	72260.
(Sn, Cl_4) liquid	127250.	+ 29920.	157170.
$(Sn, Cl_4, 2KCl)$	151400.	− 3380.	148020.
$(Pd, Cl_2, 2KCl)$	52670.	− 13630.	39040.
$(Pd, Cl_4, 2KCl)$	79060.	− 15000.	64060.
$(Pt, Cl_2, 2KCl)$	45170.	− 12220.	32950.
$(Pt, Cl_2, 2NH_4Cl)$	42550.	− 8480.	34070.
$(Pt, Cl_4, 2KCl)$	89500.	− 13760.	75740.
$(Pt, Cl_4, 2NaCl)$	73720.	+ 8540.	82260.
$(Pt, Cl_4, 2NaCl, 6H_2O)$	92890.	− 10630.	
(Te, Cl_4)	77380.	+ 20340.	97720.
(As, Cl_3) liquid	71390.	+ 17580.	88970.
(Sb, Cl_3)	91390.	....	......
(Sb, Cl_3) liquid	104870.	....	......
(Bi, Cl_3)	90630.	....	......

Oxides and Hydroxides

Reaction	Thermal effect	Reaction	Thermal effect
(K_2, O, Aq)	164560.	(Sr, O, H_2O)	146140.
(Na_2, O, Aq)	155260.	(Ca, O, H_2O)	160540.
(Li_2, O, Aq)	166520.	(Mg, O, H_2O)	148960.
(Tl_2, O, Aq)	39160.	(Mn, O, H_2O)	94770.
(Ba, O, Aq)	x + 12260.	(Zn, O, H_2O)	82680.
(Sr, O, Aq)	157780.	(Sn, O, H_2O)	68090.
(Ca, O, Aq)	163330.	(Fe, O, H_2O)	68280.
(K_2, O, H_2O)	137980.	(Cd, O, H_2O)	65680.
(Na_2, O, H_2O)	135380.	(Co, O, H_2O)	63400.
(Tl_2, O, H_2O)	45470.	(Ni, O, H_2O)	60840.
(Ba, O, H_2O)	x	(Cu, O, H_2O)	37520.

HEAT OF FORMATION (Continued)

Oxides and Hydroxides (Continued)

Reaction	Thermal effect	Reaction	Thermal effect
(Pd, O, H_2O)	22710.	(Na_2, O)	99760.
(Pt, O, H_2O)	19220.	(Tl_2, O)	42240.
(Sn, O_2, H_2O)	133500.	(Hg_2, O)	24860.
(Mn, O_2, H_2O)	116330.	(Cu_2, O)	40810.
(Pd, O_2, H_2O)	30430.	(Ag_2, O)	5900.
(Te, O_2, H_2O)	77180.	(Ba, O)	x – 22260.
$(P_2, O_3, 3H_2O)$	250320.	(Sr, O)	128440.
$(Sb_2, O_3, 3H_2O)$	167420.	(Ca, O)	145000.
$(Bi_2, O_3, 3H_2O)$	137740.	(Pb, O)	50300.
$(P_2, O_5, 3H_2O)$	400120.	(Cu, O)	37160.
$(As_2, O_5, 3H_2O)$	226180.	(Hg, O)	22000.
$(Sb_2, O_5, 3H_2O)$	228780.	(As_2, O_3)	154590.
(K, O, H, Aq)	116460.	(As_2, O_5)	219380.
(Na, O, H, Aq)	111810.	(Al_2, O_3, xH_2O)	388920.
(Li, O, H, Aq)	117440.	(Fe_2, O_3, xH_2O)	199150.
(Tl, O, H, Aq)	53760.	(Co_2, O_3, xH_2O)	149380.
(Ba, O_2, H_2, Aq)	x + 80620.	(Ni_2, O_3, xH_2O)	120380.
(Sr, O_2, H_2, Aq)	226140.	(Tl_2, O_3, xH_2O)	6340.
(Ca, O_2, H_2, Aq)	231690.	(Au_2, O_3, xH_2O)	– 13190.

Sulphides (Rhombic Sulphur)

Reaction	Thermal effect	Reaction	Thermal effect
(H_2, S, Aq)	7290.	(K, S, H, Aq)	63130.
(K_2, S, Aq)	111290.	(Na, S, H, Aq)	58480.
(Na_2, S, Aq)	101990.	(Li, S, H, Aq)	64110.
(Li_2, S, Aq)	113250.	(Ba, S_2, H_2, Aq)	x – 25770.
(Ba, S, Aq)	x – 40840.	(Sr, S_2, H_2, Aq)	119750.
(Sr, S, Aq)	104680.	(Ca, S_2, H_2, Aq)	125300.
(Ca, S, Aq)	110230.	(Mg, S_2, H_2, Aq)	110860.
(Mn, S, xH_2O)	44390.	(H_2, S)	2730.
(Zn, S, xH_2O)	39570.	(Tl_2, S)	19650.
(Cd, S, xH_2O)	32350.	(Pb, S)	18420.
(Fe, S, xH_2O)	21770.	$(Cu_2\ S)$	18260.
(Co, S, xH_2O)	19730.	(Hg, S)	6210.
(Ni, S, xH_2O)	17309.	(Ag_2, S)	3330.

x represents the unknown value (Ba, O, H_2O).

SULPHURIC ACID

Specific Gravity of Aqueous Solutions.
Lunge, Isler and Naef

(From the Chemiker Kalender, published by Julius Springer, Berlin.)

Sp. gr. at 15° C.	Deg. Bé.	Deg. Twaddell.	Per cent. H_2SO_4 by wt.	Total H_2SO_4 kg. in 1 liter.
1.000	0.0	0	0.09	0.001
1.005	0.7	1	0.95	0.009
1.010	1.4	2	1.57	0.016
1.015	2.1	3	2.30	0.023
1.020	2.7	4	3.03	0.031
1.025	3.4	5	3.76	0.039
1.030	4.1	6	4.49	0.046
1.035	4.7	7	5.23	0.054
1.040	5.4	8	5.96	0.062
1.045	6.0	9	6.67	0.071
1.050	6.7	10	7.37	0.077
1.055	7.4	11	8.07	0.085
1.060	8.0	12	8.77	0.093
1.065	8.7	13	9.47	0.102
1.070	9.4	14	10.19	0.109
1.075	10.0	15	10.90	0.117
1.080	10.6	16	11.60	0.125
1.085	11.2	17	12.30	0.133
1.090	11.9	18	12.99	0.142
1.095	12.4	19	13.67	0.150
1.100	13.0	20	14.35	0.158
1.105	13.6	21	15.03	0.166
1.110	14.2	22	15.71	0.175
1.115	14.9	23	16.36	0.183
1.120	15.4	24	17.01	0.191
1.125	16.0	25	17.66	0.199
1.130	16.5	26	18.31	0.207
1.135	17.1	27	18.96	0.215
1.140	17.7	28	19.61	0.223
1.145	18.3	29	20.26	0.231
1.150	18.8	30	20.91	0.239
1.155	19.3	31	21.55	0.248
1.160	19.8	32	22.19	0.257
1.165	20.3	33	22.83	0.266
1.170	20.9	34	23.47	0.275
1.175	21.4	35	24.12	0.283
1.180	22.0	36	24.76	0.292
1.185	22.5	37	25.40	0.301
1.190	23.0	38	26.04	0.310
1.195	23.5	39	26.68	0.319
1.200	24.0	40	27.32	0.328
1.205	24.5	41	27.95	0.337
1.210	25.0	42	28.58	0.346
1.215	25.5	43	29.21	0.355
1.220	26.0	44	29.84	0.364
1.225	26.4	45	30.48	0.373
1.230	26.9	46	31.11	0.382
1.235	27.4	47	31.70	0.391
1.240	27.9	48	32.28	0.400
1.245	28.4	49	32.86	0.409
1.250	28.8	50	33.43	0.418
1.255	29.3	51	34.00	0.426
1.260	29.7	52	34.57	0.435
1.265	30.2	53	35.14	0.444
1.270	30.6	54	35.71	0.454
1.275	31.1	55	36.29	0.462
1.280	31.5	56	36.87	0.472
1.285	32.0	57	37.45	0.481
1.290	32.4	58	38.03	0.490
1.295	32.8	59	38.61	0.500
1.300	33.3	60	39.19	0.510
1.305	33.7	61	39.77	0.519
1.310	34.2	62	40.35	0.529
1.315	34.6	63	40.93	0.538
1.320	35.0	64	41.50	0.548
1.325	35.4	65	42.08	0.557
1.330	35.8	66	42.66	0.567
1.335	36.2	67	43.20	0.577
1.340	36.6	68	43.74	0.586
1.345	37.0	69	44.28	0.596
1.350	37.4	70	44.82	0.605
1.355	37.8	71	45.35	0.614
1.360	38.2	72	45.88	0.624
1.365	38.6	73	46.41	0.633
1.370	39.0	74	46.94	0.643
1.375	39.4	75	47.47	0.653
1.380	39.8	76	48.00	0.662
1.385	40.1	77	48.53	0.672
1.390	40.5	78	49.06	0.682
1.395	40.8	79	49.59	0.692
1.400	41.2	80	50.11	0.702
1.405	41.6	81	50.63	0.711
1.410	42.0	82	51.15	0.721
1.415	42.3	83	51.66	0.730

SULPHURIC ACID (Continued)

Sp. gr. at 15° C.	Deg. Bé.	Deg. Twaddell.	Per cent. H_2SO_4 by wt.	Total H_2SO_4 kg. in 1 liter.	Sp. gr. at 15° C.	Deg. Bé.	Deg. Twaddell.	Per cent. H_2SO_4 by wt.	Total H_2SO_4 kg. in 1 liter.
1.420	42.7	84	52.15	0.740	1.645	56.6	129	72.55	1.193
1.425	43.1	85	52.63	0.750	1.650	56.9	130	72.96	1.204
1.430	43.4	86	53.11	0.759	1.655	57.1	131	73.40	1.215
1.435	43.8	87	53.59	0.769	1.660	57.4	132	73.81	1.225
1.440	44.1	88	54.07	0.779	1.665	57.7	133	74.24	1.230
1.445	44.4	89	54.55	0.789	1.670	57.9	134	74.66	1.246
1.450	44.8	90	55.03	0.798	1.675	58.2	135	75.08	1.259
1.455	45.1	91	55.50	0.808	1.680	58.4	136	75.50	1.268
1.460	45.4	92	55.97	0.817	1.685	58.7	137	75.94	1.278
1.465	45.8	93	56.43	0.827	1.690	58.9	138	76.38	1.289
1.470	46.1	94	56.90	0.837	1.695	59.2	139	76.76	1.301
1.475	46.4	95	57.37	0.846	1.700	59.5	140	77.17	1.312
1.480	46.8	96	57.83	0.856	1.705	59.7	141	77.60	1.323
1.485	47.1	97	58.28	0.865	1.710	60.0	142	78.04	1.334
1.490	47.4	98	58.74	0.876	1.715	60.2	143	78.48	1.346
1.495	47.8	99	59.22	0.885	1.720	60.4	144	78.92	1.357
1.500	48.1	100	59.70	0.896	1.725	60.6	145	79.36	1.369
1.505	48.4	101	60.18	0.906	1.730	60.9	146	79.80	1.381
1.510	48.7	102	60.65	0.916	1.735	61.1	147	80.24	1.392
1.515	49.0	103	61.12	0.926	1.740	61.4	148	80.68	1.404
1.520	49.4	104	61.59	0.936	1.745	61.6	149	81.12	1.416
1.525	49.7	105	62.06	0.946	1.750	61.8	150	81.56	1.427
1.530	50.0	106	62.53	0.957	1.755	62.1	151	82.00	1.439
1.535	50.3	107	63.00	0.967	1.760	62.3	152	82.44	1.451
1.540	50.6	108	63.43	0.977	1.765	62.5	153	83.01	1.465
1.545	50.9	109	63.85	0.987	1.770	62.8	154	83.51	1.478
1.550	51.2	110	64.26	0.996	1.775	63.0	155	84.02	1.491
1.555	51.5	111	64.67	1.006	1.780	63.2	156	84.50	1.504
1.560	51.8	112	65.20	1.017	1.785	63.5	157	85.10	1.519
1.565	52.1	113	65.65	1.027	1.790	63.7	158	85.70	1.534
1.570	52.4	114	66.09	1.038	1.795	64.0	159	86.30	1.549
1.575	52.7	115	66.53	1.048	1.800	64.2	160	86.92	1.564
1.580	53.0	116	66.95	1.058	1.805	64.4	161	87.60	1.581
1.585	53.3	117	67.40	1.068	1.810	64.6	162	88.30	1.598
1.590	53.6	118	67.83	1.078	1.815	64.8	163	89.16	1.618
1.595	53.9	119	68.26	1.089	1.820	65.0	164	90.05	1.639
1.600	54.1	120	68.70	1.099	1.821	....	...	90.20	1.643
1.605	54.4	121	69.13	1.110	1.822	65.1	...	90.40	1.647
1.610	54.7	122	69.56	1.120	1.823	....	...	90.60	1.651
1.615	55.0	123	70.00	1.131	1.824	65.2	...	90.80	1.656
1.620	55.2	124	70.42	1.141	1.825	....	165	91.00	1.661
1.625	55.5	125	70.85	1.151	1.826	65.3	...	91.25	1.666
1.630	55.8	126	71.27	1.162	1.827	....	...	91.50	1.671
1.635	56.0	127	71.70	1.172	1.828	65.4	...	91.70	1.676
1.640	56.3	128	72.12	1.182	1.829	....	...	91.90	1.681

SULPHURIC ACID (Continued)

Sp. gr. at 15°C.	Deg. Bé.	Deg. Twaddell.	Per cent. H_2SO_4 by wt.	Total H_2SO_4 kg. in 1 liter.	Sp. gr. at 15°C.	Deg. Bé.	Deg. Twaddell.	Per cent. H_2SO_4 by wt.	Total H_2SO_4 kg. in 1 liter.
1.830	....	166	92.10	1.685	1.840	65.9	168	95.60	1.759
1.831	65.5	...	92.43	1.692	1.8405	....	...	95.95	1.765
1.832	....	...	92.70	1.698	1.8410	....	...	96.38	1.774
1.833	65.6	...	92.97	1.704	1.8415	....	...	97.35	1.792
1.834	....	...	93.25	1.710	1.8410	....	...	98.20	1.808
1.835	65.7	167	93.56	1.717	1.8405	....	...	98.52	1.814
1.836	....	...	93.80	1.722	1.8400	....	...	98.72	1.816
1.837	....	...	94.25	1.730	1.8395	....	...	98.77	1.817
1.838	65.8	...	94.60	1.739	1.8390	....	...	99.12	1.823
1.839	....	...	95.00	1.748	1.8385	....	...	99.31	1.826

ACETIC ACID

Specific Gravity of Aqueous Solutions, at 15° C.

Oudemans

(From the Chemiker Kalender, published by Julius Springer.)

Specific gravity.	Pr. ct. by wt.	Specific gravity.	Per cent.	Specific gravity.	Per cent.	Specific gravity.	Per cent.
0.9992	0	1.0363	26	1.0631	52	1.0748	78
1.007	1	1.0375	27	1.0638	53	1.0748	79
1.0022	2	1.0388	28	1.0646	54	1.0748	80
1.0037	3	1.0400	29	1.0653	55	1.0747	81
1.0052	4	1.0412	30	1.0660	56	1.0746	82
1.0067	5	1.0424	31	1.0666	57	1.0744	83
1.0083	6	1.0436	32	1.0673	58	1.0742	84
1.0098	7	1.0447	33	1.0679	59	1.0739	85
1.0113	8	1.0459	34	1.0685	60	1.0736	86
1.0127	9	1.0470	35	1.0691	61	1.0731	87
1.0142	10	1.0481	36	1.0697	62	1.0726	88
1.0157	11	1.0492	37	1.0702	63	1.0720	89
1.0171	12	1.0502	38	1.0707	64	1.0713	90
1.0185	13	1.0513	39	1.0712	65	1.0705	91
1.0200	14	1.0523	40	1.0717	66	1.0696	92
1.0214	15	1.0533	41	1.0721	67	1.0686	83
1.0228	16	1.0543	42	1.0725	68	1.0674	94
1.0242	17	1.0552	43	1.0729	69	1.0660	95
1.0256	18	1.0562	44	1.0733	70	1.0644	96
1.0270	19	1.0571	45	1.0737	71	1.0625	97
1.0284	20	1.0580	46	1.0740	72	1.0604	98
1.0298	21	1.0589	47	1.0742	73	1.0580	99
1.0311	22	1.0598	48	1.0744	74	1.0553	100
1.0324	23	1.0607	49	1.0746	75		
1.0337	24	1.0615	50	1.0747	76		
1.0350	25	1.0623	51	1.0748	77		

NITRIC ACID

Specific Gravity of Aqueous Solutions

(From the Chemiker Kalender, published by Julius Springer, Berlin.)

Sp. gr. at 15° C.	Degrees Baumé.	Degrees Twaddell.	Per cent HNO_3 by weight.	Total HNO_3 kg. in 1 liter.
1.000	0.0	0	0.10	0.001
1.005	0.7	1	1.00	0.010
1.010	1.4	2	1.90	0.019
1.015	2.1	3	2.80	0.028
1.020	2.7	4	3.70	0.038
1.025	3.4	5	4.60	0.047
1.030	4.1	6	5.50	0.057
1.035	4.7	7	6.38	0.066
1.040	5.4	8	7.26	0.075
1.045	6.0	9	8.13	0.085
1.050	6.7	10	8.99	0.094
1.055	7.4	11	9.84	0.104
1.060	8.0	12	10.68	0.113
1.065	8.7	13	11.51	0.123
1.070	9.4	14	12.33	0.132
1.075	10.0	15	13.15	0.141
1.080	10.6	16	13.95	0.151
1.085	11.2	17	14.74	0.160
1.090	11.9	18	15.53	0.169
1.095	12.4	19	16.32	0.179
1.100	13.0	20	17.11	0.188
1.105	13.6	21	17.89	0.198
1.110	14.2	22	18.67	0.207
1.115	14.9	23	19.45	0.217
1.120	15.4	24	20.23	0.227
1.125	16.0	25	21.00	0.236
1.130	16.5	26	21.77	0.246
1.135	17.1	27	22.54	0.256
1.140	17.7	28	23.31	0.266
1.145	18.3	29	24.08	0.276
1.150	18.8	30	24.84	0.286
1.155	19.3	31	25.60	0.296
1.160	19.8	32	26.36	0.306
1.165	20.3	33	27.12	0.316
1.170	20.9	34	27.88	0.326
1.175	21.4	35	28.63	0.336
1.180	22.0	36	29.38	0.347
1.185	22.5	37	30.13	0.357
1.190	23.0	38	30.88	0.367
1.195	23.5	39	31.62	0.378
1.200	24.0	40	32.36	0.388
1.205	24.5	41	33.09	0.399
1.210	25.0	42	33.82	0.409
1.215	25.5	43	34.55	0.420

NITRIC ACID (Continued)

Sp. gr. at 15° C.	Degrees Baumé.	Degrees Twaddell.	Per cent HNO_3 by weight.	Total HNO_3 kg. in 1 liter.
1.220	26.0	44	35.28	0.430
1.225	26.4	45	36.03	0.441
1.230	26.9	46	36.78	0.452
1.235	27.4	47	37.53	0.463
1.240	27.9	48	38.29	0.475
1.245	28.4	49	39.05	0.486
1.250	28.8	50	39.82	0.498
1.255	29.3	51	40.58	0.509
1.260	29.7	52	41.34	0.521
1.265	30.2	53	42.10	0.533
1.270	30.6	54	42.87	0.544
1.275	31.1	55	43.64	0.556
1.280	31.5	56	44.41	0.568
1.285	32.0	57	45.18	0.581
1.290	32.4	58	45.95	0.593
1.295	32.8	59	46.72	0.605
1.300	33.3	60	47.49	0.617
1.305	33.7	61	48.26	0.630
1.310	34.2	62	49.07	0.643
1.315	34.6	63	49.89	0.656
1.320	35.0	64	50.71	0.669
1.325	35.4	65	51.53	0.683
1.330	35.8	66	52.37	0.697
1.3325	36.0	66.5	52.80	0.704
1.335	36.2	67	53.22	0.710
1.340	36.6	68	54.07	0.725
1.345	37.0	69	54.93	0.739
1.350	37.4	70	55.79	0.753
1.355	37.8	71	56.66	0.768
1.360	38.2	72	57.57	0.783
1.365	38.6	73	58.48	0.798
1.370	39.0	74	59.39	0.814
1.375	39.4	75	60.30	0.829
1.380	39.8	76	61.27	0.846
1.3833	40.0	.....	61.92	0.857
1.385	40.1	77	62.24	0.862
1.390	40.5	78	63.23	0.879
1.395	40.8	79	64.25	0.896
1.400	41.2	80	65.30	0.914
1.405	41.6	81	66.40	0.933
1.410	42.0	82	67.50	0.952
1.415	42.3	83	68.63	0.971
1.420	42.7	84	69.80	0.991
1.425	43.1	85	70.98	1.011
1.430	43.4	86	72.17	1.032
1.435	43.8	87	73.39	1.053
1.440	44.1	88	74.68	1.075

NITRIC ACID (Continued)

Sp. gr. at 15° C.	Degrees Baumé.	Degrees Twaddell.	Per cent HNO_3 by weight.	Total HNO_3 kg. in 1 liter.
1.445	44.4	89	75.98	1.098
1.450	44.8	90	77.28	1.121
1.455	45.1	91	78.60	1.144
1.460	45.4	92	79.98	1.168
1.465	45.8	93	81.42	1.193
1.470	46.1	94	82.90	1.219
1.475	46.4	95	84.45	1.246
1.480	46.8	96	86.05	1.274
1.485	47.1	97	87.70	1.302
1.490	47.4	98	89.60	1.335
1.495	47.8	99	91.60	1.369
1.500	48.1	100	94.09	1.411
1.505	48.4	101	96.39	1.451
1.510	48.7	102	98.10	1.481
1.515	49.0	103	99.07	1.501
1.520	49.4	104	99.67	1.515

HYDROCHLORIC ACID

Specific Gravity of Aqueous Solutions

(From the Chemiker Kalender, Published by Julius Springer, Berlin.)

Sp. gr. at 15° C.	Deg. Bé.	Deg. Twad-dell.	Per cent. HCl.	Total HCl kg. per liter.	Sp. gr. at 15° C.	Deg. Bé.	Deg. Twad-dell.	Per cent. HCl.	Total HCl kg. per liter.
1.000	0.0	0.0	0.16	0.0016	1.115	14.9	23	22.86	0.255
1.005	0.7	1	1.15	0.012	1.120	15.4	24	23.82	0.267
1.010	1.4	2	2.14	0.022	1.125	16.0	25	24.78	0.278
1.015	2.1	3	3.12	0.032	1.130	16.5	26	25.75	0.291
1.020	2.7	4	4.13	0.042	1.135	17.1	27	26.70	0.303
1.025	3.4	5	5.15	0.053	1.140	17.7	28	27.66	0.315
1.030	4.1	6	6.15	0.064	1.1425	18.0	..	28.14	0.322
1.035	4.7	7	7.15	0.074	1.145	18.3	29	28.61	0.328
1.040	5.4	8	8.16	0.085	1.150	18.8	30	29.57	0.340
1.045	6.0	9	9.16	0.096	1.152	19.0	..	29.95	0.345
1.050	6.7	10	10.17	0.107	1.155	19.3	31	30.55	0.353
1.055	7.4	11	11.18	0.118	1.160	19.8	32	31.52	0.366
1.060	8.0	12	12.19	0.129	1.163	20.0	..	32.10	0.373
1.065	8.7	13	13.19	0.141	1.165	20.3	33	32.49	0.379
1.070	9.4	14	14.17	0.152	1.170	20.9	34	33.46	0.392
1.075	10.0	15	15.16	0.163	1.171	21.0	..	33.65	0.394
1.080	10.6	16	16.15	0.174	1.175	21.4	35	34.42	0.404
1.085	11.2	17	17.13	0.186	1.180	22.0	36	35.39	0.418
1.090	11.9	18	18.11	0.197	1.185	22.5	37	36.31	0.430
1.095	12.4	19	19.06	0.209	1.190	23.0	38	37.23	0.443
1.100	13.0	20	20.01	0.220	1.195	23.5	39	38.16	0.456
1.105	13.6	21	20.97	0.232	1.200	24.0	40	39.11	0.469
1.110	14.2	22	21.92	0.243					

AMMONIUM HYDROXIDE

Specific Gravity of Aqueous Solutions at 15° C.

(From the Chemiker Kalender, published by Julius Springer, Berlin.)

Specific gravity	Per cent NH_3	Total NH_3 g. per liter	Specific gravity	Per cent NH_3	Total NH_3 g. per liter
1.000	0.00	0.0	0.940	15.63	146.9
0.998	0.45	4.5	0.938	16.22	152.1
0.996	0.91	9.1	0.936	16.82	157.4
0.994	1.37	13.6	0.934	17.42	162.7
0.992	1.84	18.2	0.932	18.03	168.1
0.990	2.31	22.9	0.930	18.64	173.4
0.988	2.80	27.7	0.928	19.25	178.6
0.986	3.30	32.5	0.926	19.87	184.2
0.984	3.80	37.4	0.924	20.49	189.3
0.982	4.30	42.2	0.922	21.12	194.7
0.980	4.80	47.0	0.920	21.75	200.1
0.978	5.30	51.8	0.918	22.39	205.6
0.976	5.80	56.6	0.916	23.03	210.9
0.974	6.30	61.4	0.914	23.68	216.3
0.972	6.80	66.1	0.912	24.33	221.9
0.970	7.31	70.9	0.910	24.99	227.4
0.968	7.82	75.7	0.908	25.65	232.9
0.966	8.33	80.5	0.906	26.31	238.3
0.964	8.84	85.2	0.904	26.98	243.9
0.962	9.35	89.9	0.902	27.65	249.4
0.960	9.91	95.1	0.900	28.33	255.0
0.958	10.47	100.3	0.898	29.01	260.5
0.956	11.03	105.4	0.896	29.69	266.0
0.954	11.60	110.7	0.894	30.37	271.5
0.952	12.17	115.9	0.892	31.05	277.0
0.950	12.72	121.0	0.890	31.75	282.6
0.948	13.31	126.2	0.888	32.50	288.6
0.946	13.88	131.3	0.886	33.25	294.6
0.944	14.46	136.5	0.884	34.10	301.4
0.942	15.04	141.7	0.882	34.95	308.3

POTASSIUM HYDROXIDE

Specific Gravity of Aqueous Solutions at 15° C.

Specific gravity	Deg. Baumé	Deg. Twaddell	Per cent KOH by wt.	KOH, kg. per cu. m.
1·007	1	1·4	0.9	9
1·014	2	2·8	1·7	17
1·022	3	4·4	2.6	26
1·029	4	5·8	3·5	36
1·037	5	7·4	4·5	46
1·045	6	9·0	5·6	58
1·052	7	10·4	6·4	67
1·060	8	12·0	7·4	78
1·067	9	13·4	8·2	88
1·075	10	15·0	9·2	99
1·083	11	16·6	10·1	109
1.091	12	18·2	10·9	119
1·100	13	20·0	12·0	132
1·108	14	21·6	12·9	143
1·116	15	23·2	13·8	153
1·125	16	25·0	14·8	167
1·134	17	26·8	15·7	178
1·142	18	28·4	16·5	188
1·152	19	30·4	17·6	203
1·162	20	32·4	18·6	216
1·171	21	34·2	19·5	228
1·180	22	36·0	20·5	242
1.190	23	38·0	21·4	255
1·200	24	40·0	22·4	269
1·210	25	42·0	23·3	282
1·220	26	44·0	24·2	295
1·231	27	46·2	25·1	309
1·241	28	48·2	26·1	324
1·252	29	50·4	27·0	338
1·263	30	52·6	28·0	353
1·274	31	54·8	28·9	368
1·285	32	57·0	29·8	385
1·297	33	59·4	30·7	398
1·308	34	61·6	31·8	416
1·320	35	64.0	32·7	432
1·332	36	66·4	33·7	449
1·345	37	69.0	34·9	469
1·357	38	71·4	35.9	487
1·370	39	74·0	36·9	506
1·383	40	76·6	37·8	522
1·397	41	79.4	38.9	543
1·410	42	82.0	39·9	563
1·424	43	84·8	40.9	582
1·438	44	87·6	42·1	605
1·453	45	90·6	43·4	631
1·468	46	93·6	44·6	655
1·483	47	96·6	45·8	679
1·498	48	99.6	47·1	706
1·514	49	102·8	48·3	731
1·530	50	106·0	49·4	756
1·546	51	109·2	50·6	779
1·563	52	112·6	51·9	811
1·580	53	116·0	53·2	840
1·597	54	119.4	54·5	870
1·615	55	123·0	55·9	902
1·634	56	126·8	57·5	940

SODIUM HYDROXIDE

Specific Gravity of Aqueous Solutions at 15° C.

Specific gravity	Deg. Baumé	Deg. Twaddell	Per cent NaOH by wt.	NaOH, kg. per cu. m.
1·007	1	1·4	0·59	6·0
1·014	2	2·8	1·20	12·0
1·022	3	4·4	1·85	18·9
1·029	4	5·8	2·50	25·7
1·036	5	7·2	3·15	32·6
1·045	6	9·0	3·79	39·6
1·052	7	10·4	4·50	47·3
1·060	8	12·0	5·20	55·0
1·067	9	13·4	5·86	62·5
1·075	10	15·0	6·58	70·7
1·083	11	16·6	7·30	79·1
1·091	12	18·2	8·07	88·0
1·100	13	20·0	8·78	96·6
1·108	14	21·6	9·50	105.3
1·116	15	23·2	10·30	114·9
1·125	16	25·0	11·06	124·4
1·134	17	26·8	11·90	134·9
1·142	18	28·4	12·69	145·0
1·152	19	30·4	13·50	155·5
1·162	20	32·4	14·35	166·7
1·171	21	34·2	15·15	177·4
1·180	22	36·0	16·00	188·8
1·190	23	38·0	16·91	201·2
1·200	24	40·0	17·81	213·7
1·210	25	42·0	18·71	226·4
1·220	26	44·0	19·65	239·7
1·231	27	46·2	20·60	253·6
1·241	28	48·2	21·55	267·4
1·252	29	50·4	22·50	281·7
1·263	30	52·6	23·50	296·8
1·274	31	54·8	24·48	311·9
1·285	32	57·0	25·50	327·7
1·297	33	59·4	26·58	344·7
1·308	34	61·6	27·65	361·7
1·320	35	64·0	28·83	380·6
1·332	36	66·4	30·00	399·6
1·345	37	69·0	31·20	419·6
1·357	38	71·4	32·50	441·0
1·370	39	74·0	33·73	462·1
1·383	40	76·6	35·00	484·1
1·397	41	79·4	36·36	507·9
1·410	42	82·0	37·65	530·9
1·424	43	84·8	39·06	556·2
1·438	44	87·6	40·47	582·0
1·453	45	90·6	42·02	610·6
1·468	46	93·6	43·58	639·8
1·483	47	96·6	45·16	669·7
1·498	48	99·6	46·73	700·0
1·514	49	102·8	48·41	732·9
1·530	50	106·0	50·10	766·5

POTASSIUM CARBONATE

Specific Gravity of Aqueous Solutions at 15° C.

Specific gravity	Per cent K_2CO_3	Specific gravity	Per cent K_2CO_3	Specific gravity	Per cent K_2CO_3
1·00914	1	1·18265	19	1·38279	37
1·01829	2	1·19286	20	1·39476	38
1·02743	3	1·20344	21	1·40673	39
1·03658	4	1·21402	22	1·41870	40
1·04572	5	1·22459	23	1·43104	41
1·05513	6	1·23517	24	1·44338	42
1·06454	7	1·24575	25	1·45573	43
1·07396	8	1·25681	26	1·46807	44
1·08337	9	1·25787	27	1·48041	45
1·09278	10	1·27893	28	1·49314	46
1·10258	11	1·28999	29	1·50588	47
1·11238	12	1·30105	30	1·51861	48
1·12219	13	1·31261	31	1·53135	49
1·13199	14	1·32417	32	1·54408	50
1·14179	15	1·33573	33	1·55728	51
1·15200	16	1·34729	34	1·57048	52
1·16222	17	1·35885	35	1·57079	51·024
1·17243	18	1·37082	36	......	..

SODIUM CARBONATE

Specific Gravity of Aqueous Solutions at 15° C.

Specific gravity	Per cent Na_2CO_3 $+10H_2O$	Per cent Na_2CO_3	Specific gravity	Per cent Na_2CO_3 $+10H_2O$	Per cent Na_2CO_3
1·0038	1	·370	1·0628	16	5·929
1·0076	2	.741	1·0668	17	6·299
1·0141	3	1·112	1·0708	18	6·670
1·0153	4	1·482	1·0748	19	7·011
1·0192	5	1·853	1·0789	20	7·412
1·0231	6	2·223	1·0830	21	7·782
1·0270	7	2·594	1·0871	22	8·153
1·0309	8	2·965	1·0912	23	8·523
1·0348	9	3·335	1·0953	24	8·894
1·0388	10	3·706	1·0994	25	9·264
1·0428	11	4·076	1·1035	26	9·635
1·0468	12	4·447	1·1076	27	10·005
1·0508	13	4·817	1·1117	28	10·376
1·0548	14	5·188	1·1158	29	10·746
1·0588	15	5·558	1·1200	30	11·118

ALCOHOL BY VOLUME

Tralles

Specific Gravity at 15°. 56 C.

(From the Chemiker Kalender, published by Julius Springer, Berlin.)

Per cent by vol.	Specific gravity.	Per cent by vol.	Specific gravity.	Per cent by vol.	Specific gravity.	Per cent by vol.	Specific gravity.
1	0.9976	26	0.9689	51	0.9315	76	0.8739
2	0.9961	27	0.9679	52	0.9295	77	0.8712
3	0.9947	28	0.9668	53	0.9255	78	0.8685
4	0.9933	29	0.9657	54	0.9254	79	0.8658
5	0.9919	30	0.9646	55	0.9234	80	0.8631
6	0.9906	31	0.9634	56	0.9213	81	0.8603
7	0.9893	32	0.9622	57	0.9192	82	0.8575
8	0.9881	33	0.9609	58	0.9170	83	0.8547
9	0.9869	34	0.9596	59	0.9148	84	0.8518
10	0.9857	35	0.9583	60	0.9126	85	0.8488
11	0.9845	36	0.9570	61	0.9104	86	0.8458
12	0.9834	37	0.9559	62	0.9082	87	0.8428
13	0.9823	38	0.9541	63	0.9059	88	0.8397
14	0.9812	39	0.9526	64	0.9036	89	0.8365
15	0.9802	40	0.9510	65	0.9013	90	0.8332
16	0.9791	41	0.9494	66	0.8989	91	0.8299
17	0.9781	42	0.9478	67	0.8965	92	0.8265
18	0.9771	43	0.9461	68	0.8941	93	0.8230
19	0.9761	44	0.9444	69	0.8917	94	0.8194
20	0.9751	45	0.9427	70	0.8892	95	0.8157
21	0.9741	46	0.9409	71	0.8867	96	0.8118
22	0.9731	47	0.9391	72	0.8842	97	0.8077
23	0.9720	48	0.9373	73	0.8817	98	0.8034
24	0.9710	49	0.9354	74	0.8791	99	0.7988
25	0.9700	50	0.9335	75	0.8765	100	0.7939

SPECIFIC GRAVITY OF GASES AND VAPORS

Name	Formula	Mol. wt.	Mass of 1 liter in g. 760mm. 0° C.	Density, air = 1		Density, O = 1	
				Observed	Computed	Observed	Theoret.
Acetylene	C_2H_2	26.02	1.1708	0.9056	0.9056	0.8193	0.8133
Air	......	......	1.2928	......	1.0000	......	......
Ammonia	NH_3	17.03	0.7708	0.5962	0.5963	0.5394	0.5321
Argon	A	39.88	1.7828	1.379	1.378	1.248	1.247
Bromine	Br_2	159.84	7.1388	5.524	5.524	......	......
Butane	C_4H_{10}	58.08	2.5985	2.01	......	1.82	1.8155
Carbon dioxide	CO_2	44.	1.9768	1.5288	1.5289	1.3832	1.3766
monoxide	CO	28.	1.2501	0.9670	0.9670	0.8749	0.8752
oxychloride	$COCl_2$	98.92	4.5313	3.505	......	3.171	3.0914
oxysulphide	COS	60.07	2.7201	2.104	......	1.904	1.8786
Chlorine	Cl_2	70.92	3.2204	2.491	2.4906	2.254	2.2162
monoxide	Cl_2O	86.92	3.8874	3.007	......	2.72	2.716
Cyanogen	C_2N_2	52.02	2.3348	1.806	1.8353	1.634	1.6257
Ethane	C_2H_6	30.05	1.3567	1.0494	1.0496	0.9494	0.9392
Ethyl chloride	C_2H_5Cl	64.49	2.8700	2.22	2.257	2.01	2.0159
Ethylene	C_2H_4	28.03	1.2644	0.978	0.9753	0.885	0.8762
Fluorine	F_2	38.	1.6354	1.265	......	1.145	1.187
Helium	He	7.98	0.1769	0.1368	......	0.1238	0.125
Hydrochloric acid	HCl	36.47	1.6394	1.2681	1.2683	1.1473	1.1396
Hydrofluoric acid	HF	20.01	0.9218	0.713	......	0.645	0.625
Hydriodic acid	HI	127.93	5.7245	4.428	......	4.01	4.029
Hydrogen	H_2	2.016	0.08982	0.06948	0.06949	0.06286	0.06297
selenide	H_2Se	81.21	3.6134	2.795	2.850	2.529	2.538
telluride	H_2Te	129.52	5.8034	4.489	......	4.062	4.066
Krypton	Kr	82.92	3.6431	2.818	2.832	2.550	2.556
Methane	CH_4	16.03	0.7167	0.5544	0.5544	0.5016	0.5011
Methyl chloride	CH_3Cl	50.48	2.3044	1.7825	1.785	1.6127	1.578
Neon	Ne	20.20	0.8713	0.674	......	0.610	0.625
Nitric oxide	NO	30.01	1.3401	1.0366	1.0366	0.9397	0.9391
Nitrous oxide	N_2O	44.02	1.9781	1.5301	1.5303	1.3844	1.3754
Nitrosyl chloride	NOCl	65.47	2.9864	2.31	......	2.09	2.046
Oxygen	O_2	32.	1.4289	1.1053	1.1053	1.000	1.0000
Phosphine	PH_3	34.06	1.5293	1.1829	1.1830	1.0702	1.063
Silicon fluoride	SiF_4	104.30	4.6541	3.60	......	3.26	3.259
Sulphur dioxide	SO_2	64.07	2.9268	2.2639	2.2638	2.0482	2.0034
Xenon	X	130.2	5.7168	4.422	4.506	4.001	4.00

IONIZATION CONSTANTS OF ACIDS AND BASES

Formic acid	0.000214
Acetic acid	0.000018
Chloracetic acid	0.00155
Trichloracetic acid	1.21
Benzoic acid	0.00006
Ammonium hydroxide	0.000023
Carbonic acid	0.0000003040
Hydrogen sulphide	0.0000000570
Boric acid	0.0000000017
Hydrocyanic acid	0.0000000013

DEGREE OF IONIZATION

In Normal Solution at 18° Unless Indicated

Acids

Nitric acid	0.82	† Permanganic acid	0.933
Hydrochloric acid	0.784	† Hydriodic acid	0.901
Sulfuric acid	0.510	† Hydrobromic acid	0.899
Hydrofluoric acid	0.070	† Perchloric acid	0.880
* Oxalic acid	0.500	† Chloric acid	0.878
* Tartaric acid	0.082	† Hydrochloric acid	0.876
* Acetic acid	0.004	† Phosphoric acid	0.170
* Carbonic acid	0.0017		
* Hydrogen sulfide	0.0007		
* Boric acid	0.0001		
* Hydrocyanic acid	0.0001		

* In 0.1 M. solution; primary ionization.
† In N/2 solution, at 25°.

Bases

Potassium hydroxide	0.77	‡ Strontium hydroxide	0.93
Sodium hydroxide	0.73	‡ Barium hydroxide	0.92
Barium hydroxide	0.69	‡ Calcium hydroxide	0.90
Lithium hydroxide	0.63		
Ammonium hydroxide	0.004		
Tetramethyl ammonium hydroxide	0.96		

‡ In N/64 solution, at 25°.

Salts

Approximate degree of ionization for active salts in N/10 solution:

Type R^+R^-(e.g. KCl)	0.86
Type $R^+ \ (R^-)_2$ (e.g. $BaCl_2$)	0.72
Type $(R^+)_2R^{--}$ (e.g. K_2SO_4)	0.72
Type $R^{++} R^{--}$ (e.g. $BaSO_4$)	0.45

SOLUBILITY PRODUCT

The solubility product (or ion product constant) is the product of the concentrations of the ions in the saturated solution of a difficultly soluble salt. The concentrations are expressed as moles per liter of solution. The number of cations (or anions) resulting from the dissociation of one molecule of the salt, appears in the formula for calculations of the solubility product as the exponent of the concentration of the cation (or anion).

If two solutions, each containing one of the ions of a difficultly soluble salt, are mixed, no precipitation takes place unless the product of the ion concentrations in the mixture is greater than the solubility product.

In a solution containing two salts which yield a common ion the ratio of solubilities of the two salts is the ratio of the solubility products.

Substance	Solubility product at temperature noted	Substance	Solubility product at temperature noted
Barium carbonate	1.9×10^{-9} (16°)	Manganese sulfide	1.4×10^{-15} (18°)
Barium chromate	2.4×10^{-10} (28°)	Nickel sulfide	1.4×10^{-24} (18°)
Barium oxalate	1.2×10^{-7} (25°)	Lead carbonate	3.3×10^{-14} (18°)
Barium sulfate	1.0×10^{-10} (25°)	Lead chromate	1.77×10^{-14} (18°)
Calcium carbonate	2.8×10^{-9} (16°)	Lead oxalate	3.5×10^{-11} (25°)
Calcium oxalate	2.5×10^{-7} (25°)	Lead sulfate	1.0×10^{-8} (18°)
Calcium sulfate	6.0×10^{-5} (18°)	Lead sulfide	3.4×10^{-28} (18°)
Cadmium sulfide	3.6×10^{-29} (18°)	Silver chloride	1.5×10^{-10} (25°)
Cobalt sulfide	3.0×10^{-26} (18°)	Silver bromide	4.4×10^{-13} (25°)
Cupric sulfide	8.5×10^{-45} (18°)	Silver iodide	9.0×10^{-17} (25°)
Ferrous sulfide	3.7×10^{-19} (18°)	Silver bromate	5.77×10^{-5} (25°)
Mercurous chloride	3.5×10^{-18} (25°)	Silver chromate	2.6×10^{-12} (25°)
Mercurous bromide	1.3×10^{-21} (21°)	Silver iodate	3.4×10^{-8} (25°)
Mercurous iodide	1.2×10^{-28} (25°)	Silver sulfide	1.6×10^{-49} (18°)
Mercuric sulfide	4×10^{-54} (25°)	Silver thiocyanate	1.1×10^{-12} (25°)
Magnesium carbonate	2.6×10^{-5} (12°)	Strontium oxalate	5.6×10^{-8} (18°)
Magnesium oxalate	8.5×10^{-5} (18°)	Strontium sulfate	2.8×10^{-7} (18°)
Magnesium ammonium phosphate	2.5×10^{-13} (18°)	Zinc sulfide	1.2×10^{-23} (25°)

ELECTROMOTIVE FORCE SERIES OF METALS

Alkali...Cs.Rb.K.Na.Li...			Lead	Pb	0.148
Alkaline-earth..Ba.Sr.Ca..			Hydrogen	(H)	0.000
Magnesium	Mg		Copper	Cu	0.336
Aluminum	Al	1.276	Arsenic	As	
Manganese	Mn	1.075	Bismuth	Bi	
Zinc	Zn	0.770	Antimony	Sb	
Chromium	Cr		Mercury	Hg	0.748
Cadmium	Cd	0.420	Silver	Ag	0.771
Iron	Fe	0.340	Palladium	Pd	
Cobalt	Co	0.232	Platinum	Pt	0.863
Nickel	Ni	0.228	Gold	Au	1.079
Tin	Sn	0.192			

1. Any metal will replace any other metal, *below it* in the series, from solutions of its salts, thus:

$Fe + CuSO_4$	$= FeSO_4 + Cu$	
$Zn + FeSO_4$	$= ZnSO_4 + Fe$	
$Fe + 2HCl$	$= FeCl_2 + H_2$	
$Zn + H_2SO_4$	$= ZnSO_4 + H_2$	
$Cu + HCl$	= No action.	Cu insoluble.
$Ag + HCl$	= No action.	Ag insoluble.
$Cu +$ (dilute) H_2SO_4	= No action.	
$Ag + CuSO_4$	= No action.	Ag below Cu.

Note.—It is true that dilute and conc. HNO_3 and *hot conc.* H_2SO_4 will dissolve most of the metals. When they thus dissolve metals below hydrogen in the series, the action is an oxidizing one, and the acids are reduced to NO and SO_2 respectively. The metal is first oxidized to the oxide, the acid being thus at the same time reduced, and the oxide thus formed then reacts with the acid molecule present, and goes into solution as a salt.

(*a*) $Cu +$ (dilute) H_2SO_4 = No action.
(*b*) $Cu + 2$ (hot conc.) $H_2SO_4 = CuSO_4 + SO_2 + 2H_2O$.

In (*b*), the Cu is first converted to CuO, thus

$$Cu + H_2SO_4 = CuO + H_2O + SO_2,$$

then the CuO reacts with another molecule of H_2SO_4, thus

$$CuO + H_2SO_4 = CuSO_4 + H_2O.$$
$$3Cu + 2HNO_3 = 3CuO + 2NO + H_2O$$
$$3CuO + 6HNO_3 = 3Cu(NO_3)_2 + 3H_2O$$

Added $$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 2NO + 4H_2O.$$

2. **In Regard to Ease of Reduction of Oxides.**—The metallic oxides down to and including Mn can not be completely reduced to the metal state, even in a current of hydrogen. The oxides of Cd and succeeding metals are easily reduced, and far down the list, the oxides of silver, platinum, mercury, and gold are reduced (decomposed into metal and oxygen) even by heat alone.

3. **In Regard to Ease of Rusting. (Oxidation in the Air.)**—The alkali and alkaline-earth metals rust very rapidly and with considerable evolution of heat. All the metals down to copper rust with comparative ease. The metals below copper do not rust. Assuming the electrolytic theory of the process of rusting to be true, these facts are just about what might have been predicted.

4. **In Regard to the Occurence of the Metals in the Free State in Nature.**—Natural waters are frequently dilute solutions of carbonic, nitric, humic, etc., acids. As such they contain displaceable hydrogen. Metals *above* hydrogen in the E.M.F. series scarcely, if ever, occur in the free state in nature, but are practically without exception found in the combined state, as sulphides, carbonates, etc. Metals *below* hydrogen are frequently found in the free state in nature. Thus gold is found in the form of nuggets of metallic gold. However, metals below hydrogen are also found in the combined state, as cinnabar, HgS, etc.

5. **In Regard to Action of the Metals on Water.**—The alkali and alkaline-earths metal displace hydrogen from water, even in the cold,

and with evolution of much heat. Mg and succeeding metals will displace hydrogen from steam. Metals at the bottom of the list will not displace hydrogen from steam.

6. **In Regard to the Solubility and Stability of Hydroxides.**—The alkali metal oxides have great avidity for water, forming hydroxides. The alkaline-earth metal oxides react with less readiness, forming hydroxides. MgO reacts slowly and incompletely with water, forming the hydroxide. All the other metallic oxides and hydroxides are insoluble in water and have no perceptible reaction therewith. When a solution of NaOH acts on solutions of salts of the metals, the alkali metal salts are not precipitated. The alkaline-earth metal salts are not precipitated unless in very concentrated solution. All the other metal solutions are acted upon, with precipitation of hydroxides, except in the case of copper which first gives copper hydroxide (blue), and which, on warming, changes to copper oxide (black). Also in the case of arsenic, no precipitate falls, sodium arsenite being formed. In the case of the last metals in the series, the *oxide* is precipitated, instead of the hydroxide, thus NaOH acting on salts of Sb, Hg, Ag, Pd, Pt, and Au, causes a precipitation of the *oxides* of these metals. Bismuth, as an exception, gives a normal hydroxide.

7. **In Regard to Carbonates.**—The alkali metals form normal stable, soluble carbonates, not easily decomposed on heating. The alkaline-earth metals form normal carbonates, which are insoluble in water, and which decompose upon heating, leaving the oxide, carbon dioxide being evolved. When sodium carbonate solution acts on solutions of all the other metals, as a rule, a basic carbonate is precipitated, being insoluble in water, and decomposed by heat into oxide and carbon dioxide. If the solution is cold, Ag, Hg, Cd, Fe, and Mn give normal carbonates. If the solution is warm, Sb, Hg, Ag, Pd, Pt, and Au give a precipitate of the *oxide*, instead of the carbonate, thus showing the instability of the carbonates of the lowest metals in the series.

8. **In Regard to Voltaic Cells.**—In choosing metals to acts as electrodes in voltaic cells, the farther apart the metals chosen, the greater the electromotive force of the voltaic cell. Thus the Al-Au couple gives a greater E.M.F. than the Zn-Cu couple.

For complete information, see Alex. Smith's Gen. Inorganic Chem., pages 361-363; 664–680. J. W. Mellor's Modern Inorg. Chem., pages 362–376.

TABLES SHOWING THE FUNCTIONS, USES AND COMPOSITIONS OF FOODS

Functions and Uses of Food in the Body.

Protein.—Builds and repairs tissue:

Albumen (white of eggs) Casein (curd of milk) Lean meat Gluten of grains	All serve as fuel to yield energy in the forms of heat and muscular power.

Fats.—Are stored as fat:

Fat of meats, butter, olive oil, oils of corn, wheat and other grains.

Carbohydrates.—Are transformed into fat:

Sugar, starch, etc.

Mineral Matter of Ash.—Share in forming bones and assist in processes of digestion.

Phosphates of lime potash, soda, etc.

Food is that which, taken into the body, builds tissue and yields energy.

TABLES SHOWING THE FUNCTIONS, USES AND COMPOSITIONS OF FOOD (Continued)

Dietary Standards

For a man in full vigor at moderate muscular work, per day

	Protein	Energy
	grams	calories
Food eaten	100	3.500
Food digested	95	3.200

Mineral Matter (Required per Day)

	grams
Phosphoric acid, (P_2O_5)	3 to 4
Sulphuric acid, (SO_3)	2 to 3.5
Potassium oxide, (K_2O)	2 to 3
Sodium oxide, (Na_2O)	4 to 6
Calcium oxide, (CaO)	0.7 to 1.0
Magnesium oxide, (MgO)	0.3 to 0.5
Iron, (Fe)	0.006 to 0.012
Chlorine, (Cl)	6 to 8

These tables are compiled from charts of the United States Department of Agriculture, prepared by C. F. Langworthy, expert in charge of nutrition investigations.

Name of the food material	Protein.	Fat.	Carbo-hydrates.	Ash.	Water.	Fuel value in calories per lb.
Apple	0.4	0.5	14.2	0.3	84.6	290
Bacon	9.4	67.4	....	4.4	18.8	3030
Beef suet	4.7	81.8	....	0.3	13.2	3510
Butter	1.0	85.0	....	3.0	11.0	3410
Buckwheat	10.0	2.2	73.2	2.0	12.6	1600
Beefsteak	18.6	18.5	....	1.0	61.9	1130
Buttermilk	3.0	0.5	4.8	0.7	91.0	160
Bean, fresh shelled	9.4	0.6	29.1	2.0	58.9	740
Bean, green string	2.3	0.3	7.4	0.8	89.2	195
Bean, navy dry	22.5	1.8	59.6	3.5	12.6	1600
Banana	1.3	0.6	22.0	0.8	75.3	460
Codfish, fresh	12.8	0.4	....	1.2	82.6	325
Codfish, salt	21.5	0.3	....	24.7	53.5	410
Corn, dried	10.0	4.3	73.4	1.5	10.8	1800
Corn, green	3.1	1.1	19.7	0.7	75.4	500
Corn bread	7.9	4.7	46.3	2.2	38.9	1205
Cream cheese	25.9	33.7	2.4	3.8	34.2	1950
Cottage cheese	20.9	1.0	4.3	1.8	72.0	510
Cream	2.5	18.5	4.5	0.5	74.0	865

TABLES SHOWING THE FUNCTIONS, USES AND COMPOSITIONS OF FOODS—Continued

NAME OF THE FOOD MATERIAL	PROTEIN	FAT	CARBO-HYDRATES	ASH	WATER	FUEL VALUE IN CALORIES PER LB.
Candy stick			96.5	0.5	3.0	1785
Celery	1.1		3.4	1.0	94.5	85
Chestnut	10.7	7.0	74.2	2.2	5.9	1875
Cocoanut, dried	6.3	57.4	31.5	1.3	3.5	3125
Dried beef	30.0	6.6		9.1	54.3	840
Egg, whole	14 8	10.5		1.0	73.7	700
Egg, white	13.0	0.2		0.6	86.2	265
Egg, yolk	16.1	33.3		1.1	49.5	1608
Fig, dried	4.3	0.3	74.2	2.4	18.8	1475
Fruit, canned	1.1	0.1	21.1	0.5	77.2	415
Grapes	1.3	1.6	19.2	0.5	77.4	450
Grape juice, unfermented	0.2		7.4	0.2	92.2	150
Herring, smoked	36.4	15.8		13.2	34.6	1355
Honey	0.4		81.2	0.2	18.2	1520
Jelly, fruit			78.3	0.7	21.0	1455
Lard		100.0				4080
Lamb chop	17.6	28.3		1.0	53.1	1540
Mackerel	18.3	7.1		1.2	73.4	645
Macaroni	3.0	1.5	15.8	1.3	78.4	415
Milk, whole	3.3	4.0	5.0	0.7	87.0	310
Milk, skimmed	3.4	0.3	5.1	0.7	90.5	165
Molasses	2.4		69.3	3.2	25.1	1290
Oat	11.8	5.0	69.2	3.0	11.0	1720
Olive oil		100.0				4080
Oyster	6.2	1.2	3.7	2.0	86.9	235
Onion	1.6	0.3	9.9	0.6	87.6	225
Pork chop	16.9	30.1		1.0	52.0	1580
Parsnip	1.6	0.5	13.5	1.4	83.0	230
Potato	2.2	0.1	18.4	1.0	78.3	385
Peanut	25.8	38.6	22.4	2.0	9.2	2500
Peanut butter	29.3	46.5	17.1	5.0	2.1	2825
Rye	12.2	1.5	73.9	1.9	10.5	1750
Rice	8.0	2.0	77.0	1.0	12.0	1720
Rolled oats, cooked	2.8	0.5	11.5	0.7	84.5	285
Raisins	2.6	3.3	76.1	3.4	14.6	1605
Smoked ham	16.1	38.8		4.8	40.3	1940
Sugar granulated			100.0			1860
Sugar, maple			82.8	0.9	16.3	1540
Strawberry	1.0	0.6	7.4	0.6	90.4	180
Toasted bread	11.5	1.6	61.2	1.7	24.0	1420
Wheat	12.2	1.7	73.7	1.8	10.6	1750
White bread	9.2	1.3	53.1	1.1	35.3	1215
Whole wheat bread	9.7	0.9	49.7	1.3	38.4	1140
Walnut	16.6	63.4	16.1	1.4	2.5	3285

PROPERTIES OF MATTER

DENSITY OF VARIOUS SOLIDS

The approximate density of various solids at ordinary atmospheric temperature.

(Selected from Smithsonian Tables.)

Substance.	Grams per cu.cm.	Pounds per cu.ft.	Substance.	Grams per cu.cm.	Pounds per cu.ft.
Agate	2.5–2.7	156–168	Mica	2.6–3.2	165–200
Amber	1.06–1.11	66–69	Paraffin	0.87–0.91	54–57
Asbestos	2.0–2.8	125–175	Pitch	1.07	67
Asphalt	1.1–1.5	69–94	Porcelain	2.3–2.5	143–156
Beeswax	0.96–0.97	60–61	Quartz	2.65	165
Brass	8.20–8.78	511–548	Resin	1.07	67
Brick	1.4–2.2	87–137	Rock salt	2.28–2.41	142–150
Bronze	8.74–8.89	545–555	Soapstone	2.6–2.8	162–175
Butter	0.86–0.87	53–54	Starch	1.53	95
Calcspar	2.6–2.8	162–175	Sugar	1.61	100
Cement, powder	1.15–1.7	72–105	Tallow	0.91–0.97	57.0–60.5
set	2.7–3.0	168–187	Wood, ash	0.65–0.85	40–53
Chalk	1.9–2.8	118–175	bamboo	0.31–0.40	19–25
Clay, dry	1.8–2.6	122–162	beech	0.70–0.90	43–56
Coal, soft	1.2–1.5	75–94	birch	0.51–0.77	32–48
anthracite	1.4–1.8	87–112	box	0.95–1.16	59–72
Cork	0.22–0.26	14–16	butternut	0.38	24
Ebonite	1.15	72	cedar	0.49–0.57	30–35
Emery	4.0	250	cherry	0.70–0.90	43–56
Feldspar	2.53–2.58	158–161	ebony	1.11–1.33	69–83
Flint	2.63	164	elm	0.54–0.60	34–37
Galena	7.3–7.6	460–470	hickory	0.60–0.93	37–58
Garnet	3.6–3.8	230–335	lignumvitæ	1.17–1.33	73–83
Gas carbon	1.88	119	mahogany	0.66–0.85	......
German silver	8.30–8.45	518–527	maple	0.62–0.75	39–47
Glass, common	2.4–2.8	150–175	oak	0.60–0.90	37–56
flint	2.9–5.9	180–370	pine, white	0.35–0.50	22–31
Ice	0.88–0.91	55–57	pitch	0.83–0.85	52–53
Ivory	1.83–1.92	114–120	poplar	0.35–0.5	22–31
Marble	2.5–2.8	157–177			

For specific gravity of the elements and of inorganic compounds, see pages 14 to 41.

DENSITY OF WATER

The temperature of maximum density for pure water, free from air = **3°.98** C.

The density at this temperature = **0.999973** (C. G. S.).

(International Bureau of Weights and Measures, 1910.)

DENSITY OF VARIOUS LIQUIDS

(Selected from Smithsonian Tables.)

Liquid.	Grams per cu.cm.	Pounds per cu.ft.	Temp. °C.
Acetone	0.792	49.4	0°
Alcohol, ethyl	0.791	49.4	0
methyl	0.810	50.5	0
Benzene	0.899	56.1	0
Carbolic acid	0.950–0.965	59.2–60.2	15
Chloroform	1.480	92.3	18
Ether	0.736	45.9	0
Gasoline	0.66–0.69	41.0–43.0	..
Glycerine	1.260	78.6	0
Milk	1.028–1.035	64.2–64.6	..
Naphtha, wood	0.848–0.810	52.9–50.5	0
Naphtha, petroleum ether	0.665	41.5	15
Oils:			
castor	0.969	60.5	15
cocoanut	0.925	57.7	15
cotton seed	0.926	60.2	16
creosote	1.040–1.100	64.9–68.6	15
linseed, boiled	0.942	58.8	15
olive	0.918	57.3	15
turpentine	0.873	54.2	16
Sea water	1.025	64.0	15

HYDROMETER CONVERSION TABLES

Showing the Relation between Density (C. G. S.) and Degrees Baumé for Densities less than Unity.

Density.	Degrees Baumé.				
	.00	.01	.02	.03	.04
0.60	103.33	99.51	95.81	92.22	88.75
.70	70.00	67.18	64.44	61.78	59.19
.80	45.00	42.84	40.73	38.68	36.67
.90	25.56	23.85	22.17	20.54	18.94
1.00	10.00	.....	.....	.....	.....

Density.	Degrees Baumé.				
	.05	.06	.07	.08	.09
0.60	85.38	82.12	78.95	75.88	72.90
.70	56.67	54.21	51.82	49.49	47.22
.80	34.71	32.79	30.92	29.09	27.30
.90	17.37	15.83	14.33	12.86	11.41
1.00	......	.....	.....	.....	.....

HYDROMETER CONVERSION TABLES
(Continued)

Showing the Relation between Density (C. G. S.) and the Baumé and Twaddell Scales for Densities above Unity.

Density.	Degrees Baumé.	Degrees Twaddell.	Density.	Degrees Baumé.	Degrees Twaddell.
1.00	0.00	0	1.41	42.16	82
1.01	1.44	2	1.42	42.89	84
1.02	2.84	4	1.43	43.60	86
1.03	4.22	6	1.44	44.31	88
1.04	5.58	8	1.45	45.00	90
1.05	6.91	10	1.46	45.68	92
1.06	8.21	12	1.47	46.36	94
1.07	9.49	14	1.48	47.03	96
1.08	10.74	16	1.49	47.68	98
1.09	11.97	18	1.50	48.33	100
1.10	13.18	20	1.51	48.97	102
1.11	14.37	22	1.52	49.60	104
1.12	15.54	24	1.53	50.23	106
1.13	16.68	26	1.54	50.84	108
1.14	17.81	28	1.55	51.45	110
1.15	18.91	30	1.56	52.05	112
1.16	20.00	32	1.57	52.64	114
1.17	21.07	34	1.58	53.23	116
1.18	22.12	36	1.59	53.80	118
1.19	23.15	38	1.60	54.38	120
1.20	24.17	40	1.61	54.94	122
1.21	25.16	42	1.62	55.49	124
1.22	26.15	44	1.63	56.04	126
1.23	27.11	46	1.64	56.58	128
1.24	28.06	48	1.65	57.12	130
1.25	29.00	50	1.66	57.65	132
1.26	29.92	52	1.67	58.17	134
1.27	30.83	54	1.68	58.69	136
1.28	31.72	56	1.69	59.20	138
1.29	32.60	58	1.70	59.71	140
1.30	33.46	60	1.71	60.20	142
1.31	34.31	62	1.72	60.70	144
1.32	35.15	64	1.73	61.18	146
1.33	35.98	66	1.74	61.67	148
1.34	36.79	68	1.75	62.14	150
1.35	37.59	70	1.76	62.61	152
1.36	38.38	72	1.77	63.08	154
1.37	39.16	74	1.78	63.54	156
1.38	39.93	76	1.79	63.99	158
1.39	40.68	78	1.80	64.44	160
1.40	41.43	80	....	.....	...

ABSOLUTE DENSITY OF WATER

Density in Grams per Cubic Centimeter, Computed from the Relative Values by Thiesen, Scheel and Disselhorst (1900), and the Absolute Value at 3°.98 C. by the International Bureau of Weights and Measures (1910).

Degrees	0	1	2	3	4	5	6	7	8	9
0	0.999841	847	854	860	866	872	878	884	889	895
1	900	905	909	914	918	923	927	930	934	938
2	941	944	947	950	953	955	958	960	962	964
3	965	967	968	969	970	971	972	972	973	973
4	973	973	973	972	972	972	970	969	968	966
5	965	963	961	959	957	955	952	950	947	944
6	941	938	935	931	927	924	920	916	911	907
7	902	898	893	888	883	877	872	866	861	855
8	849	843	837	830	824	817	810	803	796	789
9	781	774	766	758	751	742	734	726	717	709
10	700	691	682	673	664	654	645	635	625	615
11	605	595	585	574	564	553	542	531	520	509
12	498	486	475	463	451	439	427	415	402	390
13	377	364	352	339	326	312	299	285	272	258
14	244	230	216	202	188	173	159	144	129	114
15	099	084	069	054	038	023	007	*991	*975	*959
16	0.998943	926	910	893	877	860	843	826	809	792
17	774	757	739	722	704	686	668	650	632	613
18	595	576	558	539	520	501	482	463	444	424
19	405	385	365	345	325	305	285	265	244	224
20	203	183	162	141	120	099	078	056	035	013
21	0.997992	970	948	926	904	882	860	837	815	792
22	770	747	724	701	678	655	632	608	585	561
23	538	514	490	466	442	418	394	369	345	320
24	296	271	246	221	196	171	146	120	095	069
25	044	018	*992	*967	*941	*914	*888	*862	*836	*809
26	0.996783	756	729	703	676	649	621	594	567	540
27	512	485	457	429	401	373	345	317	289	261
28	232	204	175	147	118	089	060	031	002	*973
29	0.995944	914	885	855	826	796	766	736	706	676
30	646	616	586	555	525	494	464	433	402	371

RELATIVE DENSITY AND VOLUME OF WATER

The mass of one cubic centimeter of water at 4° C is taken as unity.
The absolute density in C. G. S. units is obtained by multiplying the relative density by 0.999973.

(Smithsonian Tables, compiled from Various Authors.)

Temp. ° C.	Density.	Volume.	Temp. ° C.	Density.	Volume
−10	0.99815	1.00186	+35	0.99406	1.00598
−9	843	157	36	371	633
−8	869	131	37	336	669
−7	892	108	38	299	706
−6	912	088	39	262	743
−5	0.99930	1.00070	40	0.99224	1.00782
−4	945	055	41	186	821
−3	958	042	42	147	861
−2	970	031	43	107	901
−1	979	021	44	066	943
+0	0.99987	1.00013	45	0.99025	1.00985
1	993	007	46	0.98982	1.01028
2	997	003	47	940	072
3	999	001	48	896	116
4	1.00000	1.00000	49	852	162
5	0.99999	1.00001	50	0.98807	1.01207
6	997	003	51	762	254
7	993	007	52	715	301
8	988	012	53	669	349
9	981	019	54	621	398
10	0.99973	1.00027	55	0.98573	1.01448
11	963	037	60	324	705
12	952	048	65	059	979
13	940	060	70	0.97781	1.02270
14	927	073	75	489	576
15	0.99913	1.00087	80	0.97183	1.02899
16	897	103	85	0.96865	1.03237
17	880	120	90	534	590
18	862	138	95	192	959
19	843	157	100	0.95838	1.04343
20	0.99823	1.00177	110	0.9510	1.0515
21	802	198	120	0.9434	1.0601
22	780	221	130	0.9352	1.0693
23	756	244	140	0.9264	1.0794
24	732	268	150	0.9173	1.0902
25	0.99707	1.00294	160	0.9075	1.1019
26	681	320	170	0.8973	1.1145
27	654	347	180	0.8866	1.1279
28	626	375	190	0.8750	1.1429
29	597	405	200	0.8628	1.1590
30	0.99567	1.00435	210	0.850	1.177
31	537	466	220	0.837	1.195
32	505	497	230	0.823	1.215
33	473	530	240	0.809	1.236
34	440	563	250	0.794	1.259

DENSITY AND VOLUME OF MERCURY

Based on the Density of Mercury at 0° C. by Thiesen and Scheel (1898)

(Selected from Smithsonian Tables.)

Temp. ° C.	Mass in gr. per cu.cm.	Vol. of 1 gr. in cu.cms.	Temp. ° C.	Mass in gr. per cu.cm.	Vol. in 1 gr. in cu.cms.
−10	13.6202	0.0734205	30°	13.5217	0.0739552
−9	6177	4338	31	5193	9686
−8	6152	4472	32	5168	9820
−7	6128	4606	33	5144	9953
−6	6103	4739	34	5119	40087
−5	13.6078	0.0734873	35	13.5095	0.0740221
−4	6053	5006	36	5070	0354
−3	6029	5140	37	5046	0488
−2	6004	5273	38	5021	0622
—1	5979	5407	39	4997	0756
0	13.5955	0.0735540	40	13.4973	0.0740891
1	5930	5674	50	4729	2229
2	5906	5808	60	4486	3569
3	5881	5941	70	4244	4910
4	5856	6075	80	4003	6252
5	13.5832	0.0736209	90	13.3762	0.0747594
6	5807	6342	100	3522	8939
7	5782	6476	110	3283	50285
8	5758	6610	120	3044	1633
9	5733	6744	130	2805	2982
10	13.5708	0.0736877	140	13.2567	0.0754334
11	5684	7011	150	2330	5688
12	5659	7145	160	2093	7044
13	5634	7278	170	1856	8402
14	5610	7412	180	1620	9764
15	13.5585	0.0737546	190	13.1384	0.0761128
16	5561	7680	200	1148	2495
17	5536	7813	210	0913	3865
18	5512	7947	220	0678	5239
19	5487	8081	230	0443	6616
20	13.5462	0.0738215	240	13.0209	0.0767996
21	5438	8348	250	12.9975	9381
22	5413	8482	260	9741	70769
23	5389	8616	270	9507	2161
24	5364	8750	280	9273	3558
25	13.5340	0.0738883	290	12.9039	0.0774958
26	5315	9017	300	8806	6364
27	5291	9151	310	8572	7774
28	5266	9285	320	8339	9189
29	5242	9419	330	8105	80609
30	13.5217	0.0739552	340	12.7872	0.0782033
			350	7638	3464
			360	7405	4900

DENSITY OF AQUEOUS SOLUTIONS

(Selected from Smithsonian Tables.)

Substance.	Density in grams per cubic centimeter. Parts of solute in 100 parts of solution by weight.									Temp. ° C.
	5	10	15	20	25	30	40	50	60	
Ammonium chloride	1.015	1.030	1.044	1.058	1.072	...	...	...	...	15.
Barium chloride	1.045	1.094	1.147	1.205	1.269	...	...	...	...	15.
Cadmium chloride	1.043	1.087	1.138	1.193	1.254	1.319	1.469	1.653	1.887	19.5
Calcium chloride	1.041	1.086	1.132	1.181	1.232	1.286	1.402	...	...	15.
Cane sugar	1.019	1.039	1.060	1.082	1.129	1.178	1.289	...	...	17.5
Copper sulphate	1.031	1.064	1.098	1.134	1.173	1.213	...	...	...	18.
Mercuric chloride	1.041	1.092	...	...	...	...	...	...	...	20.
Potassium bichromate	1.035	1.071	1.108	...	...	...	...	...	...	19.5
hydroxide	1.040	1.082	1.027	1.076	1.229	1.286	1.410	1.538	1.666	15.
chloride	1.031	1.065	1.099	1.135	...	...	...	...	...	15.
bromide	1.035	1.073	1.114	1.157	1.205	1.254	1.364	...	...	19.5
iodide	1.036	1.076	1.118	1.164	1.216	1.269	1.394	1.544	1.732	19.5
nitrate	1.031	1.064	1.099	1.135	...	...	...	...	...	15.
Sodium hydroxide	1.058	1.114	1.169	1.224	1.279	1.331	1.436	1.539	1.642	15.
chloride	1.035	1.072	1.110	1.150	1.191	...	...	...	...	15.
Silver nitrate	1.044	1.090	1.140	1.195	1.255	1.322	1.479	1.675	1.918	15.
Zinc chloride	1.043	1.089	1.135	1.184	1.236	1.289	1.417	1.563	1.737	19.5
sulphate	1.027	1.057	1.089	1.122	1.156	1.191	1.269	1.351	1.443	20.5

DENSITY OF ALCOHOL

Density of Ethyl Alcohol in Grams per Cubic Centimeter, Computed from Mendelejeff's Formula

(Selected from Smithsonian Tables.)

Temp. ° C.	0	1	2	3	4
0	.80625	.80541	.80457	.80374	.80290
10	.79788	.79704	.79620	.79535	.79451
20	.78945	.78860	.78775	.78691	.78606
30	.78097	.78012	.77927	.77841	.77756

Temp. ° C.	5	6	7	8	9
0	.80207	.80123	.80039	.79956	.79872
10	.79367	.79283	.79198	.79114	.79029
20	.78522	.78437	.78352	.78267	.78182
30	.77671	.77585	.77500	.77414	.77329

DENSITY OF DRY AIR

AT THE TEMPERATURE t, AND UNDER THE PRESSURE H CM. OF MERCURY, THE DENSITY OF AIR

$$=\frac{0.001293}{1+0.00367\,t}\,\frac{H}{76}.$$

(From Miller's Laboratory Physics, Ginn & Co. publishers, by permission.)

t	Pressure H in Centimeters.					
	72.0	73.0	74.0	75.0	76.0	77.0
°						
10	0.001182	0.001198	0.001215	0.001231	0.001247	0.001264
11	178	193	210	227	243	259
12	173	190	206	222	239	255
13	169	186	202	218	234	251
14	165	181	198	214	230	246
15	0.001161	0.001177	0.001193	0.001210	0.001226	0.001242
16	157	173	189	205	221	238
17	153	169	185	201	217	233
18	149	165	181	197	213	229
19	145	161	177	193	209	225
20	0.001141	0.001157	0.001173	0.001189	0.001205	0.001221
21	137	153	169	185	201	216
22	134	149	165	181	197	212
23	130	145	161	177	193	208
24	126	142	157	173	189	204
25	0.001122	0.001138	0.001153	0.001169	0.001185	0.001200
26	118	134	149	165	181	196
27	115	130	146	161	177	192
28	111	126	142	157	173	188
29	107	123	138	153	169	184
30	0.001104	0.001119	0.001134	0.001150	0.001165	0.001180

Proportional Parts.

cm.	17	16	15
0.1	2	2	1
0.2	3	3	3
0.3	5	5	4
0.4	7	6	6
0.5	8	8	7
0.6	10	10	9
0.7	12	11	10
0.8	14	13	12
0.9	15	14	13

DENSITY OF SATURATED VAPORS AT THE TEMPERATURE OF NORMAL EBULLITION

Vapor.	Temp. ° C.	Density.
Acetic acid	118.5	0.00315
Benzene	80.2	0.00275
Chloroform	61.2	0.00443
Ether	34.6	0.00311
Ethyl alcohol	78.3	0.00164
Methyl alcohol	64.7	0.00121
Water	100.0	0.000596

DENSITY OF GASES IN LIQUID AND SOLID FORM

Temperatures marked * are the temperatures of normal ebullition.

Gas.	Liquid.		Solid.		Observer.
	Temp. ° C.	D g/cm³.	Temp. ° C.	D g/cm³.	
Acetylene	− 23.5	0.52	.....	....	Mathias, 1909
	30.3	0.40	.....	....	
Air (20.9% oxygen)	−147.	0.92	.....	....	
Ammonia	− 10.7	0.65	.....	....	Andreeff, 1859
	+ 16.3	0.61	.....	....	Andreeff, 1859
Argon	−187.*	1.41	.....	....	Baly & Donnan, 1902
Carbon dioxide	− 60.	1.19	− 79.	1.53	Behn, 1910
	+ 20.	0.77	.....	....	Amagat
Carbon monoxide	−190.*	.79	.....	....	
	− 68.	.86	.....	....	Baly & Donnan
Chlorine	− 33.6*	1.56	.....	....	Knietsch, 1890
Chlorine	+ 20.	1.41	.....	....	Knietsch, 1890
Ethylene	− 21.	0.41	.....	....	Cailletet & Mathias, 1886
Ethylene	+ 10.	0.21			
Helium	−269.*	0.122	.....	....	Kamerling-Onnes & Perrier, 1910
Hydrogen	−253.*	0.07	−260.	.076	Dewar, 1904
Hydrogen sulphide	− 61.	0.86			
Nitrogen	−196.*	0.804	−253.	1.03	Dewar, 1904
Nitrous oxide	− 20.	1.0	.....	....	Cailletet & Mathias
Nitrous oxide	+ 17.	.80	.....	....	Villard, 1897
Oxygen	− 23.	0.89	.....	....	Cailletet & Hautefeuille, 1881
	−182.7*	1.14	−253.	−1.41	Kamerling-Onnes & Perrier, 1910
	−205.	1.25	.....	....	Baly & Donnan
Sulphur dioxide	− 10.*	1.46	.....	....	Pierre
	+ 20.	1.38	.....	....	Cailletet & Mathias

ELASTIC CONSTANTS FOR SOLIDS

YOUNG'S MODULUS AND MODULUS OF RIGIDITY

The values can be considered only as approximations. They are for ordinary atmospheric temperatures.

Material.	Young's Modulus.		Modulus of rigidity.	
	Dynes per sq.cm.	Pounds per sq.in.	Dynes per sq.cm.	Pounds per sq.in.
Aluminum	7×10^{11}	10.2×10^{6}	2.5×10^{11}	3.63×10^{6}
Bismuth	3.2	4.65	1.24	1.80
Brass	9.2	13.4	3.7	5.38
Bronze	10.6	15.4	4.06	5.91
phosphor	12.0	17.4	4.36	6.32
Cadmium	5.0	7.26	2.45	3.56
Copper	10.	14.5	4.2	6.10
German silver	10.8	15.7	4.5	6.54
Glass ordinary	4.7–7.8	6.83–11.3	1.8–3.2	2.62–4.65
crown	6.5–7.8	9.45–11.3	2.6–3.2	3.78–4.65
flint	5.0–6.0	7.26–8.52	2.0–2.5	2.91–3.63
Gold, pure	8.0	11.6	3.0	4.36
Granite	1.46	2.12		
Ice	.28	.407		
Iron, drawn	20.0	29.1	8.00	11.6
cast	11.5	16.8	5.10	7.41

ELASTIC CONSTANTS FOR SOLIDS (Continued)

Young's Modulus and Modulus of Rigidity (Continued)

Gas.	Young's Modulus.		Modulus of rigidity.	
	Dynes per sq.cm.	Pounds per sq.in.	Dynes per sq.cm.	Pounds per sq.in.
Ivory	$.9\times10^{11}$	1.31×10^6		
Lead	1.7	2.47	0.7×10^{11}	1.02×10^6
Magnesium	4.2	6.10	1.7	2.47
Manganin	12.4	18.0	4.65	6.70
Nickel	22.0	32.0	8.0	11.6
Platinum	17.0	24.7	6.5	9.45
Platinum-iridium	21.4	31.1		
Quartz, crystal:				
‖ to axis	10.30	15.0		
⊥ to axis	7.85	11.4		
fiber	5.6	8.14	3.0	4.36
Rhodium	28.0	40.7		
Silver, pure	7.5	10.9	2.7	3.94
Steel, ordinary mild	22.0	32.0	8.00	11.6
cast	19.5	28.3	7.50	10.9
drawn	18.8	27.3		
invar	14.1	20.3	5.63	8.18
Tantalum	18.6	27.0		
Tin	5.0	7.26	2.0	2.91
Wood	.03–1.0	.0436–1.45		
Zinc	9.0	13.1	3.4	4.94

Bulk Modulus, Limit of Elasticity and Breaking Strain

The values can be considered only as approximations. They are for ordinary atmospheric temperatures.

Material.	Limit of Elasticity.		Breaking Strain.		Bulk Modulus Dynes per sq.cm.
	Dynes per sq.cm.	Pounds per sq.in.	Dynes per sq.cm.	Pounds per sq.in.	
Aluminum	5.0×10^8	7.25×10^3	$10–25\times10^8$	$14.5–36.3\times10^3$	7.0×10^{11}
Bismuth	......	....	....	....	3.0
Brass	......	....	22.–48.	32.–70.	6.1
Bronze	5.0–12.	7.25–17.4	20.–40.	29.–58.	8.9
Cadmium	......	....	....	....	4.12
Copper	0.5–20.0	0.73–29.0	16.–45.	23.2–65.3	12.0
German silver	......	....	....	....	15.0
Glass:					
crown	......	....	....	....	4.0–5.9
flint	......	....	....	....	3.6–3.8
Gold	......	....	11.0	15.6	16.0
Iron:					
drawn	20.	29.	66.	96.	15.4
cast	17.	25.	33.	48.	9.6
Lead	......	....	3.	4.4	0.76
Manganin	......	....	....	....	12.1
Nickel	......	....	42.	61.	17.0
Platinum	......	....	36.	52.	24.0
Quartz	......	....	....	....	3.7
Silver	15.	22.	28.	41.	10.0
Steel, mild	20.–100.	29.–145.	35.–150.	51.–218.	16.0
Tin	......	....	8.	12.	5.0
Zinc	......	....	6.	8.7	3.5

COMPRESSIBILITY OF LIQUIDS

Contraction in Unit Volume per Atmosphere Pressure

(From Smithsonian Tables.)

Liquid.	Temp. ° C.	Pressures in atmosphere.	Coefficient.	Observer.
Acetone......	0.00	1–500	82×10^{-6}	Amagat, 1893
Acetone......	99.5	8.94–36.5	276.	Amagat, 1883
Benzol.......	17.9	8	92.	Röntgen, 1891
Carbon bisulphide......	0.00	1–500	66.	Amagat, 1893
Carbon bisulphide......	49.2	1000–1500	51.	Amagat, 1893
Chloroform...	20.	....	128.	Grimaldi, 1887
Chloroform...	100.	8–9	211.	Amagat, 1883
Ethyl alcohol.	20.	1–50	112.	Amagat, 1893
Ethyl alcohol.	20.	300–400	78.	Amagat, 1893
Ethyl alcohol.	28.	150–400	81.	Barus, 1890–1–2
Ethyl alcohol.	100.	150–200	168.	Barus, 1890–1–2
Ethyl alcohol.	185.	150–400	245.	Barus, 1890–1–2
Ethyl alcohol.	310.	150–400	1530.	Barus, 1890–1–2
Glycerine.....	20.5	....	25.	Quincke, 1893
Mercury......	0.	....	3.92	Amagat, 1891
Nitric acid....	20.3	1–32	338.	Colladon-Sturm, 1828
Water........	0.	1–25	525.	Amagat, 1893
Water........	10.	1–25	500.	Amagat, 1893
Water........	20.	1–25	491.	Amagat, 1893
Water........	0.	25–50	516.	Amagat, 1893
Water........	10.	25–50	492.	Amagat, 1893
Water........	20.	25–50	476.	Amagat, 1893
Water........	0.	100–200	492.	Amagat, 1893
Water........	10.	100–200	461.	Amagat, 1893
Water........	20.	100–200	442.	Amagat, 1893
Water........	50.	100–200	425.	Amagat, 1893
Water........	100.	100–200	468.	Amagat, 1893
Water........	0.	500–1000	416.	Amagat, 1893
Water........	0.	1000–1500	358.	Amagat, 1893
Water........	0.	1500–2000	324.	Amagat, 1893
Water........	0.	2000–2500	292.	Amagat, 1893
Water........	0.	2500–3000	261.	Amagat, 1893

ELASTIC CONSTANTS FOR GASES

For short ranges of pressure, at a constant temperature, the volume of a gas is inversely proportional to the pressure or pressure × volume = a constant. (Boyle's Law.)

For high pressures, the table below shows the relative volumes at various temperatures. The volume at 0° C. and 76 cm. pressure (1 atmosphere) being taken as 1,000,000.

(From Smithsonian Tables.)

Atm.	Oxygen.			Air.		
	0°	99°.5	199°.5	0°	99°.4	200°.4
100	9265	......	....	9730		
200	4570	7000	9095	5050	7360	9430
300	3208	4843	6283	3658	5170	6622
400	2629	3830	4900	3036	4170	5240
500	2312	3244	4100	2680	3565	4422
600	2115	2867	3570	2450	3180	3883
700	1979	2610	3202	2288	2904	3502
800	1879	2417	2929	2168	2699	3219
900	1800	2268	2718	2070	2544	3000
1000	1735	2151	......	1992	2415	2828

Atm.	Nitrogen.			Hydrogen.		
	0°	99°.5	199°.6	0°	99°.3	200°.5
100	9910					
200	5195	7445	9532	5690	7567	9420
300	3786	5301	6715	4030	5286	6520
400	3142	4265	5331	3207	4147	5075
500	2780	3655	4515	2713	3462	4210
600	2543	3258	3973	2387	3006	3627
700	2374	2980	3589	2149	2680	3212
800	2240	2775	3300	1972	2444	2900
900	2149	2616	3085	1832	2244	2657
1000	2068	......	......	1720	2093	

COEFFICIENT OF FRICTION

(From Rankine's Compilation, 1858; Smithsonian Tables.)

Materials.	Coefficient of friction.	Angle of repose in degrees.
Wood on wood, dry	.25–.50	14.0–26.5
Wood on wood, soapy	.20	11.5
Metals on oak, dry	.50–.60	26.5–31.0
Metals on oak, wet	.24–.26	13.5–14.5
Metals on oak, soapy	.20	11.5
Metals on elm, dry	.20–.25	11.5–14.0
Hemp on oak, dry	.53	28.0
Hemp on oak, wet	.33	18.5
Leather on oak	.27–.38	15.0–19.5
Leather on metals, dry	.56	29.5
Leather on metals, wet	.36	20.0
Leather on metals, greasy	.23	13.0
Leather on metals, oily	.15	8.5
Metals on metals, dry	.15–.20	8.5–11.5
Metals on metals, wet	.3	16.5
Smooth surfaces occasionally greased	.07–.08	4.0–4.5
Smooth surfaces continually greased	.05	3.0
Smooth surfaces, best results	.03–.036	1.75–2.0
Steel on agate, dry	.20	11.5
Steel on agate, oiled	.107	6.1
Iron on stone	.30–.70	16.7–35.0
Wood on stone	about .40	22.0
Masonry and brick work, dry	.60–.70	33.0–35.0
Masonry and brick work, damp mortar	.74	36.5
Masonry on dry clay	.51	27.0
Masonry on moist clay	.33	18.25
Earth on earth	.25–1.00	14.0–45.0
Earth on earth, dry sand, clay and mixed earth	.38–.75	21.0–37.0
Earth on earth, damp clay	1.00	45.0
Earth on earth, wet clay	.31	17.0
Earth on earth, shingle and gravel	.81–1.11	39.0–48.0

RESISTANCE TO CRUSHING FOR VARIOUS MATERIALS

Approximate values in pounds per square inch.

Material.	Resistance to crushing in lbs. per sq. in.	Material.	Resistance to crushing in lbs. per sq.in.
Brick:		Granite	9700–34000
soft burned	3000–6000	Limestone	6000–25000
hard burned	4500–6500	Marble	7600–20700
vitrified	8500–25000	Sandstone	2400–29300
Brownstone	7300–23600	Tufa	7700–11600
Concrete	800–3800		

TENSILE STRENGTH OF METALS

(Selected from Smithsonian Tables.)

Given in pounds per square inch. The values can be considered only as approximations.

Metal.	Tensile Strength in lbs. per sq.in.
Aluminum wire	30000–40000
Brass wire	50000–150000
Bronze wire, phosphor, hard drawn	110000–140000
Bronze wire, silicon, hard drawn	95000–115000
Bronze	60000–75000
Copper wire, hard drawn	60000–70000
Gold wire	20000
Iron, cast	13000–33000
Iron wire, hard drawn	80000–120000
Iron wire, annealed	50000–60000
Lead, cast or drawn	2600–3300
Palladium	39000
Platinum wire	50000
Silver wire	42000
Steel	80000–330000
Steel wire, maximum	460000
Steel, specially treated nickel steel	250000
Steel, piano wire, 0.033 in. diam	357000–390000
Steel, piano wire, 0.051 in. diam	325000–337000
Tin, cast or drawn	4000–5000
Zinc, cast	7000–13000
Zinc, drawn	22000–30000

MODULUS OF RUPTURE. TRANSVERSE TESTS FOR VARIOUS WOODS

(Smithsonian Tables.)

Material.	Modulus, lbs. per sq.in.	Material.	Modulus, lbs. per sq.in.
Ash, white	10,800	Maple, sugar	16,500
Basswood	8,340	Maple, white	14,640
Beech	16,200	Oak, red	11,400
Cedar, red	11,800	Oak, white	13,100
Cedar, white	6,300	Pine, white	7,900
Cypress, bald	7,900	Pine, red	9,100
Elm, white	10,300	Poplar	9,400
Fir, red	13,270	Spruce, pine	10,000
Hemlock	9,480	Walnut, black	11,900
Hickory, pignut	18,700		

HARDNESS

Scale of Hardness

1	Talc	4	Fluorite	8	Topaz
2	Rocksalt	5	Apatite	9	Corundum
3	Calcite	6	Feldspar	10	Diamond
		7	Quartz		

Hardness of Materials

The numbers give only the order of arrangement as to hardness.

(From Smithsonian Tables.)

Agate	7.	Hematite	6.
Alabaster	1.7	Hornblende	5.5
Alum	2–2.5	Iridium	6.
Aluminum	2.	Iridosmium	7.
Amber	2–2.5	Iron	4–5.
Andalusite	7.5	Kaolin	1.
Anthracite	2.2	Lead	1.5
Antimony	3.3	Loess (0°)	0.3
Apatite	5.	Magnetite	6.
Aragonite	3.5	Marble	3–4.
Arsenic	3.5	Meerschaum	2–3.
Asbestos	5.	Mica	2.8
Asphalt	1–2.	Opal	4–6.
Augite	6.	Orthoclase	6.
Barite	3.3	Palladium	4.8
Beryl	7.8	Phosphor bronze	4.
Bell-metal	4.	Platinum	4.3
Bismuth	2.5	Plat-iridium	6.5
Boric acid	3.	Pyrite	6.3
Brass	3–4.	Quartz	7.
Calanime	5.	Rock-salt	2.
Calcite	3.	Ross' metal	2.5–3.0
Copper	2.5–3.	Silver chloride	1.3
Corundum	9.	Sulphur	1.5–2.5
Diamond	10.	Stibnite	2.
Dolomite	3.5–4.	Serpentine	3–4.
Feldspar	6.	Silver	2.5–3.
Flint	7.	Steel	5–8.5
Fluorite	4.	Talc	1.
Galena	2.5	Tin	1.5
Garnet	7.	Topaz	8.
Glass	4.5–6.5	Tourmaline	7.3
Gold	2.5–3.	Wax (0°)	0.2
Graphite	0.5–1.	Wood's metal	3.
Gypsum	1.6–2.	Zinc	2.5

SURFACE TENSION OF VARIOUS LIQUIDS IN CONTACT WITH AIR

(Compiled from Various Sources.)

Liquid.	Temp. ° C.	Tension, dynes per cm.	Observer.
Acetic acid	20	23.5	Ramsay & Shields
Acetone	17.6	23.3	Jaeger
Alcohol, ethyl	20	21.7	Magie
Alcohol, methyl	20	23.0	Ramsay & Shields
Anilin	17.5	44.1	Volkmann
Benzol (C_6H_6)	22.5	29.4	Cantor
Bromine	−21	62.1	Quincke
Carbon disulphide	20	31.7	Magie
Chloroform	20	26.7	Magie
Ether	20	16.8	Brunner
Glycerine	18	65.2	Cantor
Hydrochloric acid	20	72.9	Quincke
Mercury	18	520.	
Oil, olive	20	33.5	Mean of various
Oil, turpentine	20	27.1	Mean of various
Petroleum	20	25.9	Magie

SURFACE TENSION OF AQUEOUS SOLUTIONS

Salt in solution.	Density of solution.	Temp. ° C.	Tension in dynes per cm. against air.
Barium chloride	1.282	15–16	81.8
Calcium chloride	1.351	19	95.0
Calcium chloride	1.277	19	90.2
Copper sulphate	1.178	15–16	78.6
Hydrochloric acid	1.119	20	73.6
Hydrochloric acid	1.089	20	74.5
Hydrochloric acid	1.024	20	75.3
Potassium chloride	1.170	15–16	82.8
Potassium chloride	1.101	15–16	80.1
Sodium chloride	1.193	20	85.8
Sodium chloride	1.107	20	80.5
Sodium nitrate	1.302	12	83.5
Sodium oleate	saturated	20	25.0
Sulphuric acid	1.445	15	79.7
Sulphuric acid	1.264	15	79.7
Zinc sulphate	1.398	15–16	83.3
Zinc sulphate	1.104	15–16	77.8

SURFACE TENSION OF FUSED SOLIDS

(With One Exception from Quincke, 1868.)

Substance.	Gas with which liquid is in contact.	Temp. ° C.	Surface tension, dynes per cm.
Antimony	CO_2	432.	245.
Borax	air	fusion	212.
Copper	air	fusion	581.
Gold *	air	1070	612.
Iron	air	fusion	950.
Lead	CO_2	330	448.
Phosphorus	CO_2	fusion	41.2
Platinum	air	2000	1658.
Potassium	....	58	371.
Potassium chloride	....	fusion	93.
Silver	air	1000	782.
Selenium	air	fusion	70.
Sodium	....	90	258.
Sodium chloride	....	fusion	115.
Sugar	air	160	66.9
Sulphur	air	111	42.
Tin	CO_2	fusion	352.
Zinc	....	360	877.

* Heydweiller.

SURFACE TENSION OF WATER AND ALCOHOL

SURFACE TENSION FOR WATER AND ALCOHOL (ETHYL) IN CONTACT WITH AIR IN DYNES PER CENTIMETER

(From Smithsonian Tables.)

Temp. ° C.	Surface tension, dynes per centimeter.		Temp. ° C.	Surface tension, dynes, per centimeter.	
	Water.	Ethyl alcohol.		Water.	Ethyl alcohol.
0	75.6	23.5	55	67.8	18.6
5	74.9	23.1	60	67.1	18.2
10	74.2	22.6	65	66.4	17.8
15	73.5	22.2	70	65.7	17.3
20	72.8	21.7	75	65.0	16.9
25	72.1	21.3	80	64.3	
30	71.4	20.8	85	63.6	
35	70.7	20.4	90	62.9	
40	70.0	20.0	95	62.2	
45	69.3	19.5	100	61.5	
50	68.6	19.1			

VISCOSITY OF WATER AND OTHER LIQUIDS

(1) Thorpe-Rogers, 1894; (2) Gartenmeister, 1890.

Temp. °C.	Coefficient of viscosity, C. G. S.							
	Water (1)	Alcohol, ethyl (1)	Chloroform (1)	Ether (2)	Benzol (1)	Acetic acid (2)	Carbon bisulphide (1)	Amyl acetate (2)
0	1.000	.01770	.00700	....	.00902	.....	.00429	
10	.733	.01449	.00626	.0026	.00759	.0150	.00396	.0106
20	.564	.01192	.00564	.0023	.00649	.0126	.00367	.0089
30	.449	.00990	.00511	.0021	.00562	.0109	.00342	.0077
40	.368	.00828	.00466	....	.00492	.0094	.00319	.0065
50	.308	.00698	.00390	....	.00437	.0082	.....	.0058
60	.263							
70	.228	.00504	.....	....	.00351			
80	.200							
90	.178							

VISCOSITY OF LIQUIDS

Coefficient of Viscosity in C. G. S. Units

Liquid.	Temp. °C.	Viscosity.	Observer.
Acetone	20.	.0033	Thorpe-Rogers
Air, liquid	.....	0.0033	Forch
Bromine	16.	0.010	Thorpe-Rogers
Carbon dioxide (liquid)	20.	0.00071	Warburg-Babo
Glycerine	2.8	42.2	Schottner
	20.3	8.3	Schottner
Mercury	0.	0.0170	Koch
	20.	0.0157	Koch
	300.	0.0093	Koch
Olive oil	15.	0.9890	Brodmann
Sulphuric acid	20.	0.22	Graham

VISCOSITY OF GASES

C. G. S. Units.

Gas.	Temp. °C.	Viscosity.	Observer.
Air	0.	0.000173	Breitenbach
Carbon dioxide	−20.	0.000129	Breitenbach
	15.	0.000145	Breitenbach
Chlorine	20.	0.000147	Graham
Hydrogen	0.	0.000086	Markowski
Nitrogen	10.9	0.000171	Obermayer
Oxygen	0.	0.000193	Markowski
Water vapor	0.	0.000090	Puluj
	100.	0.000132	Meyer-Schumann

DIFFUSION

Gases into Air

Gas or vapor.	Temp. C.	Coefficient of diffusion, sq.cm./sec.	Observer.
Alcohol, vapor	40.4	0.137	Winkelmann
Carbon dioxide	0.0	0.139	Mean of various
Carbon disulphide	19.9	0.102	Winkelmann
Ether, vapor	19.9	0.089	Winkelmann
Hydrogen	0.0	0.634	Obermayer
Oxygen	0.0	0.178	Obermayer
Water, vapor	8.0	0.239	Guglielmo

Aqueous Solutions into Pure Water

Concentration in gram-molecules per liter.

Substance.	Concentration.	Temp. ° C.	Diffusion sq.cm./day.	Observer.
Acetic acid	0.2	13.5	0.77	Scheffer
	1.0	12.	0.74	Arrhenius
	2.0	12.	0.69	Arrhenius
	3.0	12.	0.68	
	4.0	12.	0.66	Arrhenius
Ammonia	1.0	15.23	1.54	Abegg
Barium chloride	0.2	8.	0.66	Scheffer
Bromine	0.1	12.	0.8	Euler
Cadmium sulphate	2.0	19.04	0.246	Seitz
Calcium chloride	2.0	10.	0.68	Schuhmeister
Chlorine	0.1	12.	1.22	Euler
Copper sulphate	0.1	17.	0.39	Thovert
Formic acid	1.0	12.	0.97	Abegg
Glycerine	0.1	10.14	0.357	Heimbrodt
	0.2	10.1	3.55	Heimbrodt
	1.0	10.14	0.339	Heimbrodt
Hydrochloric acid	0.1	19.2	2.21	Thovert
	1.0	12.	2.09	Arrhenius
	2.0	12.	2.21	Arrhenius
Iodine	0.1	12.	(0.5)	Euler
Magnesium sulphate	1.0	7.	0.30	Scheffer
Nitric acid	0.1	19.5	2.07	Thovert
Potassium bromide	1.0	10.	1.13	Schuhmeister
carbonate	3.0	10.	0.60	Schuhmeister
chloride	0.1	17.5	1.38	Thovert
chloride	4.0	10.	1.27	Schuhmeister
hydrate	0.1	13.5	1.72	Thovert
	1.0	12.	1.72	Arrhenius
	3.0	12.	1.89	Arrhenius
Silver nitrate	0.1	12.	0.985	Thovert
Sodium acetate	0.2	12.	0.67	Kawalki
chloride	0.1	15.0	0.94	Thovert
	0.2	15.0	0.94	Thovert
	1.0	15.0	0.94	Thovert
	1.0	14.3	0.964	Heimbrodt
hydrate	1.0	12.	1.11	Thovert
iodide	1.0	10.	0.80	Schuhmeister
	2.0	10.	0.90	Schuhmeister
Sugar	1.0	12.	0.254	Arrhenius
Sulphuric acid	1.0	12.	1.12	Arrhenius
	2.0	12.	1.16	Arrhenius
Urea	0.1	14.8	0.97	Heimbrodt
	0.2	14.8	0.969	Heimbrodt
Zinc acetate	2.0	18.05	0.210	Seitz
	2.0	0.04	0.120	Seitz
sulphate	1.0	14.8	0.236	Seitz

OSMOTIC PRESSURE OF AQUEOUS SOLUTIONS

For a Membrane of Ferrocyanide of Copper

Dissolved Substance.	Gms.substance in 1 cm. sol.	Temp. ° C.	Pressure, cm. Hg.	Observer.
Glycerine..........	.00199	0	36.7	
Gum arabic.........	0.0099	15.5	7.0	Pfeffer
Gum arabic.........	0.164	15.6	119.3	Pfeffer
Phenol (carbolic acid)	.00127	0	23.3	Naccari
	Gm.-mol. substance per gm. sol.		**Pressure in atm.**	
Glucose............	.0001	10.2	2.39	Morse,1911
	.0005	10.2	11.55	Morse,1911
	.0010	10.0	23.80	Morse,1911
Saccharose (cane sugar)............	.0001	10.0	2.50	Morse,1911
	.0005	10.0	12.30	Morse,1911
	.0010	10.0	25.69	Morse,1911
	Gm.-mol. substance in 1 ccm. sol.			
Potassium carbonate	.00005	15	1.17	Adie, 1891
ferrocyanide......	.00005	15	3.44	Adie, 1891
nitrate...........	.00005	15	1.56	Adie, 1891
Sodium citrate (acid)	.00005	15	4.32	Adie, 1891

CONVERSION OF THERMOMETER SCALES

Degrees C. $\times 1.8 + 32 =$ Degrees F.

Degrees $\dfrac{(F. - 32)4}{9} =$ Degrees R.

Degrees $\dfrac{F. - 32}{1.8} =$ Degrees C.

Degrees $\dfrac{R. \times 5}{4} =$ Degrees C.

Degrees $\dfrac{R. \times 9}{4} + 32 =$ Degrees F.

Degrees $\dfrac{C. \times 4}{5} =$ Degrees R.

CENTIGRADE-FAHRENHEIT THERMOMETER SCALE REDUCTIONS

The values given in the body of the table show the temperatures on the Fahrenheit scale corresponding to that on the Centigrade scale given at the top and side.

Temp. ° C.	0	1	2	3	4	5	6	7	8	9
0	32.0	33.8	35.6	37.4	39.2	41.0	42.8	44.6	46.4	48.2
10	50.0	51.8	53.6	55.4	57.2	59.0	60.8	62.6	64.4	66.2
20	68.0	69.8	71.6	73.4	75.2	77.0	78.8	80.6	82.4	84.2
30	86.0	87.8	89.6	91.4	93.2	95.0	96.8	98.6	100.4	102.2
40	104.0	105.8	107.6	109.4	111.2	113.0	114.8	116.0	118.4	120.2
50	122.0	123.8	125.6	127.4	129.2	131.0	132.8	134.6	136.4	138.2
60	140.0	141.8	143.6	145.4	147.2	149.0	150.8	152.6	154.4	156.2
70	158.0	159.8	161.6	163.4	165.2	167.0	168.8	170.6	172.4	174.2
80	176.0	177.8	179.6	181.4	183.2	185.0	186.8	188.6	190.4	192.2
90	194.0	195.8	197.6	199.4	201.2	203.0	204.8	206.6	208.4	210.2
100	212.0									

C°	0	10	20	30	40	50	60	70	80	90
−200	−328	−346	−364	−382	−400	−418	−436	−454	....	....
−100	−148	−166	−184	−202	−220	−238	−256	−279	−292	−310
−0	32	14	−4	−22	−40.	−58	−76	−94	−112	−130
+0	32	50	68	86	104	122	140	158	176	194
100	212	230	248	266	284	302	320	338	356	374
200	392	410	428	446	464	482	500	518	536	554
300	572	590	608	626	644	662	680	698	716	734
400	752	770	788	806	824	842	860	878	896	914
500	932	950	968	986	1004	1022	1040	1058	1076	1094
600	1112	1130	1148	1166	1184	1202	1220	1238	1256	1274
700	1292	1310	1328	1346	1364	1382	1400	1418	1436	1454
800	1472	1490	1508	1526	1544	1562	1580	1598	1616	1634
900	1652	1670	1688	1706	1724	1742	1760	1778	1796	1814
1000	1832	1850	1868	1886	1904	1922	1940	1958	1976	1994
1100	2012	2030	2048	2066	2084	2102	2120	2138	2156	2174
1200	2192	2210	2228	2246	2264	2282	2300	2318	2336	2354
1300	2372	2390	2408	2426	2444	2462	2480	2498	2516	2534
1400	2552	2570	2588	2606	2624	2642	2660	2678	2696	2714
1500	2732	2750	2768	2786	2804	2822	2840	2558	2876	2894
1600	2912	2930	2948	2966	2984	3002	3020	3038	3056	3074
1700	3092	3110	3128	3146	3164	3182	3200	3218	3236	3254
1800	3272	3290	3308	3326	3344	3362	3380	3398	3416	3434
1900	3452	3470	3488	3506	3524	3542	3560	3578	3596	3614
2000	3632	3650	3668	3686	3704	3722	3740	3758	3776	3794

For interpolation in the above table

C.	1	2	3	4	5	6	7	8	9	10
F.	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2	18.

REDUCTION OF MERCURY IN GLASS THERMOMETER READING TO THE HYDROGEN SCALE

JENA NORMAL GLASS, 16III

(From Miller's Laboratory Physics, Ginn & Co., publishers, by permission.)

Reading......	0°	10	20	30	40	50
Correction....	0°.000	−0.055	−0.090	−0.109	−0.115	−0.109
Reading......	50°	60	70	80	90	100
Correction....	−0°.109	−0.096	−0.076	−0.053	−0.027	0.000

COEFFICIENTS OF THERMAL EXPANSION

Linear Expansion

(Compiled from Smithsonian Tables.)

The Table gives the increase in length per unit length per degree Centigrade.

Substance.	Temp. ° C.	Coefficient.	Observer.
Aluminum	40	0.2313×10^{-4}	Fizeau
Aluminum	600	0.3150	Chatelier
Antimony	15–101	0.1088	Grüneisen, 1910
Bismuth	19–101	0.1345	Grüneisen, 1910
Brass, cast	0–100	0.1875	Smeaton
Brass, wire	0–100	0.1930	Smeaton
Bronze 3Cu+1Sn	16.6–100	0.1844	Daniell
86.3Cu+ 9.7Sn+4Zn	40	0.1782	Fizeau
Cadmium	20–100	0.416	Grüneisen, 1910
Carbon diamond	40	0.0118	Fizeau
gas carbon	40	0.0540	Fizeau
graphite	40	0.0786	Fizeau
anthracite	40	0.2078	Fizeau
Cobalt	40	0.1236	Fizeau
Constantine	4–29	0.4570	
Copper	40	0.1678	Fizeau
Copper	−191–+16	0.1409	Henning
Ebonite	25.3–35.4	0.842	Kohlrausch
German silver	0–100	0.1836	Pfaff
Glass, tube	0–100	0.0833	Smeaton
crown (mean)	0–100	0.0897	Lavoisier and Laplace
flint	50–60	0.0788	Pulfrich
Jena thermometer	0–100	0.081	Schott
Gold	40	0.1443	Fizeau
Gutta percha	20	1.983	Russner
Ice	−20 to −1	0.51	Mean
Iceland spar:			
‖ to axis	0–80	0.2631	Benoit
⊥ to axis	0–80	0.0544	Benoit
Iridium	0–100	0.0682	Holborn and Day, 1901
Iron, pure	0–100	0.1216	Guillaume, 1912
soft	40	0.1210	Fizeau
cast	40	0.1061	Fizeau
cast	−191–+16	0.0850	Henning
steel	40	0.1322	Fizeau
Lead	40	0.2924	Fizeau
Magnesium	18–100	0.2608	Grüneisen, 1910
Marble	15–100	0.117	Fröhlich
Nickel	0–100	0.1310	Guillaume

COEFFICIENTS OF THERMAL EXPANSION (Continued)

Linear Expansion

The Table gives the increase in length per unit length per degree Centigrade.

Substance.	Temp. ° C.	Coefficient.	Observer.
Phosphorus	0–40	1.2530×10^{-4}	Pisati and De Franchis
Platinum-iridium 10Pt+1Ir	40	0.0884	Fizeau
Platinum	40	0.0899	Fizeau
Porcelain	20–790	0.0413	Braun
Potassium	0–50	0.8300	Hagen
Quartz crystal:			
‖ to axis	0–80	0.0797	Benoit
⊥ to axis	0–80	0.1337	Benoit
fused	0–200	0.00518	Randall, 1910
fused	0–1200	0.00585	Randall, 1910
Rhodium	40	0.0850	Fizeau
Rock salt	40	0.4040	Fizeau
Selenium	40	0.3680	Fizeau
Silver	40	0.1921	Fizeau
Speculum metal	0–100	0.1933	Smeaton
Sulphur crystal (mean)	40	0.6413	Fizeau
Tin	18–100	0.2692	Grüneisen, 1910
Tungsten	20–100	0.0336	Colin, 1910
Vulcanite	0–18	0.6360	Mayer
Wood:			
ash parallel to fibre	0–100	0.0951	Glatzel
beech	2–34	0.0257	Villari
chestnut	2–34	0.0649	Villari
elm	2–34	0.0565	Villari
mahogany	2–34	0.0361	Villari
maple	2–34	0.0638	Villari
oak	2–34	0.0492	Villari
pine	2–34	0.0541	Villari
walnut	2–34	0.0658	Villari
Across the fibre:			
beech	2–34	0.614	Villari
chestnut	2–34	0.325	Villari
elm	2–34	0.443	Villari
mahogany	2–34	0.404	Villari
maple	2–34	0.484	Villari
oak	2–34	0.544	Villari
pine	2–34	0.341	Villari
walnut	2–34	0.484	Villari
Zinc	40	0.2918	Fizeau

EQUATION FOR THE LINEAR EXPANSION OF SOLIDS

If l_0 is the length at 0° C. the length at t° C. is $l_t = l_0\ (1 + \alpha t + \beta t^2)$.

The table gives the values of these coefficients.

Substance.	Temp. limits. ° C.	α.	β.	Observer.
Aluminum...	10–90	$.2221 \times 10^{-4}$	$.114 \times 10^{-7}$	Fizeau
Brass.......	10–90	.1781	.098	Fizeau
Copper......	10–90	.1596	.102	Fizeau
Gold........	10–90	.1410	.042	Fizeau
Iron, pure...	0–38	.1145	.071	Guillaume
Lead........	10–90	.2829	.120	Fizeau
Nickel......	0–38	.1255	.057	Guillaume
Platinum....	0–1000	.0868	.013	Holborn and Valentine
Silver.......	10–90	.1862	.074	Fizeau
Tin.........	10–90	.2094	.175	Fizeau
Zinc........	10–90	.2969	−.0635	Fizeau

CUBICAL EXPANSION OF SOLIDS

The coefficient of cubical expansion for a solid is approximately three times the linear coefficient.

The experimental values for various solids are given in the following table. The coefficient is the increase in volume per unit volume per degree Centigrade.

Substance.	Temp. ° C.	Coefficient.	Observer.
Antimony.......	0–100	0.3167×10^{-4}	Matthieson
Bismuth........	....	0.4000	Kopp
Diamond........	40	0.0354	Fizeau
Fluor spar.......	14–47	0.6235	Kopp
Glass, white tube.	0–100	0.2648	Regnault
green tube.....	0–100	0.2299	Regnault
Jena..........	0–100	0.2533	Reichsanstalt
Ice............	−20 to −1	1.1250	Brunner
Iceland spar.....	50–60	0.1447	Pulfrich
Iron............	0–100	0.3550	Dulong and Petit
Porcelain........	0–100	0.1080	Deville and Troost
Quartz..........	50–60	0.3530	Pulfrich
Rock salt........	50–60	1.2120	Pulfrich

CUBICAL EXPANSION OF LIQUIDS

The table gives the mean coefficient of cubical expansion for the range 0–100° C. and the values of the quantities α, β and γ in the equation $V_t = V_0\ (1 + \alpha t + \beta t^2 + \gamma t^3)$.

(From Smithsonian Tables.)

Liquid.	Temp. Range ° C.	Mean coef. 0-100° C.	α	β	γ	Observer.
Acetic acid	16–107	.001433	1.0630×10^{-3}	0.1264×10^{-6}	1.0876×10^{-8}	Zander
Acetone	0–54	1616	1.3240	3.8090	0.8798	Zander
Alcohol:						
amyl	−15 to +80	.....	0.8900	0.6573	1.1846	Pierre
ethyl, sp.gr. .8095	0–80	.....	1.0414	0.7836	1.7168	Kopp
ethyl, 50% by volume	0–39	.....	0.7450	1.850	0.730	Recknagel
ethyl, 30% by volume	18–39	.....	0.2928	17.900	11.87	Recknagel
methyl	−38 to +70	1433	1.1856	1.5649	0.9111	Pierre
Benzene	11–81	1385	1.1763	1.2775	0.8065	Kopp
Bromine	− 7 to +60	1168	1.0382	1.7114	0.5447	Pierre
Calcium chloride:						
$CaCl_2$, 5.8% solution	18–25	0506	0.0788	4.2742	....	Decker
$CaCl_2$, 40.9% solution	17–24	0510	0.4238	0.8571	....	Decker
Carbon disulphide	−34 to +60	1468	1.1398	1.3706	1.9122	Pierre
Chloroform	0–63	1399	1.1071	4.6647	1.7433	Pierre
Ether	−15 to +38	2150	1.5132	2.3592	4.0051	Pierre
Glycerine	....	0534	0.4853	0.4895	....	Emo
Hydrochloric acid:						
$HCl+6.25H_2O$	0–30	0489	0.4460	0.430	....	Marignac
$HCl+50H_2O$	0–30	0933	0.0625	8.710	....	Marignac

CUBICAL EXPANSION OF LIQUIDS (Continued)

Liquid.	Temp. Range ° C.	Mean coef. 0-100° C.	α	β	γ	Observer.
Mercury	24–299	.....	0.18182×10^{-3}	0.00078×10^{-6}	....	Scheel
Olive oil	....	.000742	0.6821	1.1405	$-.539\times10^{-8}$	Spring
Potassium chloride:						
KCl, 2.5% solution	....	0572	....	....	....	Decker
KCl, 24.3% solution	....	0477	....	....	....	Decker
Potassium nitrate:						
KNO_3, 5.3% solution	....	0539	....	....	....	Nicol
KNO_3, 21.9% solution	....	0577	....	....	....	Nicol
Phenol, C_6H_6O	36–157	0899	0.8340	0.1073	0.4446	Pinette
Petroleum, sp.gr. 0.8467	24–120	1039	0.8994	1.396	....	Frankenheim
Sodium chloride, NaCl, 1.6% solution	....	1067	0.0213	10.462	....	Marignac
Sodium sulphate, Na_2SO_4, 24% solution	10–40	0611	0.3599	2.516	....	Marignac
Sodium nitrate, $NaNO_3$, 36.2% solution	20–78	0627	0.5408	1.075	....	Nicol
Sulphuric acid:						
H_2SO_4	0–30	0489	0.5758	0.864	....	Marignac
$H_2SO_4+50H_2O$	0–30	0799	0.2835	5.160	....	Marignac
Turpentine	−9 to +106	1051	0.9003	1.959	....	Kopp
Water	0–33	.....	−.0643	8.505	6.790	Scheel

COEFFICIENTS OF EXPANSION OF GASES AT CONSTANT PRESSURE

Change in volume per unit volume per degree Centigrade.

(From Smithsonian Tables.)

Gas.	Temp. ° C.	Pressure in cm. of mercury.	Coefficient.	Observer.
Acetylene	0	76.	.003772	Leduc, 1912
Acetylene	0–100	76.	3739	Leduc, 1912
Air	0–100	76.	3670	Regnault, 1842
Air	0–100	100.1	36728	Chappuis, 1903
Ammonia	0	76.	3860	Leduc, 1912
Ammonia	0–100	76.	3800	Leduc, 1912
Carbon dioxide	0	76.	3751	Leduc, 1912
Carbon dioxide	0–100	76.	3723	Leduc, 1912
Carbon dioxide	0–20	51.8	37128	Chappuis, 1903
Carbon dioxide	0–40	51.8	37100	Chappuis, 1903
Carbon dioxide	0–100	51.8	37073	Chappuis, 1903
Carbon dioxide	0–20	99.8	37602	Chappuis, 1903
Carbon dioxide	0–100	99.8	37410	Chappuis, 1903
Carbon dioxide	0–20	137.7	37972	Chappuis, 1903
Carbon dioxide	0–100	137.7	37703	Chappuis, 1903
Carbon dioxide	0–7.5	2621.	1097	Baly-Ramsay, 1894
Carbon dioxide	64–100	2621.	6574	Baly-Ramsay, 1894
Carbon monoxide	0–100	76.	3669	Regnault, 1842
Chlorine	0	76.	3900	Leduc, 1912
Chlorine	0–100	76.	3830	Leduc, 1912
Cyanogen	0	76.	396	Leduc, 1912
Cyanogen	0–100	76.	387	Leduc, 1912
Hydrochloric acid	0	76.	3770	Leduc, 1912
Hydrochloric acid	0–100	76.	3734	Leduc, 1912
Hydrogen	0–100	100.0	36600	Chappuis, 1903
Hydrogen	0–100	200. atm	332	Amagat, 1890
Hydrogen	0–100	400. atm	295	Amagat, 1890
Hydrogen	0–100	600. atm	261	Amagat, 1890
Hydrogen	0–100	800. atm	242	Amagat, 1890
Nitrogen	0	76.	3673	Leduc, 1912
Nitrogen	0–100	76.	3671	Leduc, 1912
Nitrous oxide	0–100	76.	3719	Regnault, 1842
Oxygen	0–100	100. atm	486	Amagat
Oxygen	0–100	200. atm	534	Amagat
Oxygen	0–100	400. atm	459	Amagat
Oxygen	0–100	600. atm	357	Amagat
Oxygen	0–100	800. atm	288	Amagat
Oxygen	0–100	1000. atm	241	Amagat
Sulphur dioxide	0–100	76.	3903	Regnault, 1842
Sulphur dioxide	....	98.	3980	Regnault, 1842
Water vapor	0–119	76.	4187	Hirn, 1862
Water vapor	0–141	76.	4189	Hirn, 1862
Water vapor	0–162	76.	4071	Hirn, 1862
Water vapor	0–200	76.	3938	Hirn, 1862
Water vapor	0–247	76.	3799	Hirn, 1862

COEFFICIENT OF EXPANSION OF GASES AT CONSTANT VOLUME

Change in pressure per unit pressure per degree Centigrade.

(From Smithsonian Tables.)

Gas.	Temp. ° C.	Pressure cm. of Hg.	Coefficient.	Observer.
Acetylene	0	76.	.003741	Leduc, 1912
Acetylene	0–100	76.	3726	Leduc, 1912
Air	.....	.6	37666	Meleander, 1890–92
Air	.....	1.3	37127	Meleander, 1890–92
Air	.....	10.0	36630	Meleander, 1890–92
Air	.....	25.4	36580	Meleander, 1890–92
Air	.....	75.2	36660	Meleander, 1890–92
Air	0–100	100.1	36744	Chappuis, 1903
Air	.....	76.0	36650	Regnault, 1842
Air	.....	200.0	36903	Regnault, 1842
Air	.....	2000.	38866	Regnault, 1842
Air	.....	10000.	4100	Regnault, 1842
Ammonia	0	76.	3800	Leduc, 1912
Ammonia	0–100	76.	3770	Leduc, 1912
Argon	.....	51.7	3668	Keunen-Randall, 1896
Carbon dioxide	0–20	51.8	36985	Chappuis, 1903
Carbon dioxide	0–40	51.8	36972	Chappuis, 1903
Carbon dioxide	0–100	51.8	36981	Chappuis, 1903
Carbon dioxide	0–20	99.8	37335	Chappuis, 1903
Carbon dioxide	0–100	99.8	37262	Chappuis, 1903
Carbon dioxide	0–100	100.0	37248	Chappuis, 1892
Carbon dioxide	0	76.	3724	Leduc, 1912
Carbon dioxide	0–100	76.	3714	Leduc, 1912
Carbon monoxide	.....	76.	36667	Regnault, 1842
Cyanogen	0	76.	3870	Leduc, 1912
Cyanogen	0–100	76.	3830	Leduc, 1912
Ethane	0	76.	3780	Leduc, 1912
Ethane	0–100	76.	3750	Leduc, 1912
Helium	.....	56.7	3665	Keunen-Randall, 1896
Hydrochloric acid	.....	76.	3740	Leduc, 1912
Hydrochloric acid	0–100	76.	3721	Leduc, 1912
Hydrogen	0	76.	3663	Leduc, 1912
Hydrogen	0–100	76.	3664	Leduc, 1912
Hydrogen	16–132	.0077	3328	Baly-Ramsay, 1894
Hydrogen	15–132	.025	3623	Baly-Ramsay, 1894
Hydrogen	12–105	.47	3656	Baly-Ramsay, 1894
Hydrogen	0–100	100.0	36626	Chappuis, 1903
Methane	0	76.	3680	Leduc, 1912
Methane	0–100	76.	3678	Leduc, 1912
Nitrogen	0	76.	3672	Leduc, 1912
Nitrogen	0–100	76.	3672	Leduc, 1912
Nitrogen	13–132	.06	3021	Baly-Ramsay, 1894
Nitrogen	9–133	.53	3290	Baly-Ramsay, 1894
Nitrogen	0–20	100.2	36754	Chappuis, 1903
Nitrogen	0–100	100.2	36744	Chappuis, 1903
Oxygen	0	76.	3673	Leduc, 1912
Oxygen	0–100	76.	3672	Leduc, 1912
Oxygen	11–132	.007	4161	Baly-Ramsay, 1894
Oxygen	9–132	.25	3984	Baly-Ramsay, 1894
Oxygen	11–132	.51	3831	Baly-Ramsay, 1894
Oxygen	.....	1.9	36683	Meleander, 1891
Oxygen	.....	18.5	36690	Meleander, 1891
Nitrous oxide	.....	76.	3676	Regnault, 1842
Sulphur dioxide, SO_2	.....	76.	3845	Regnault, 1842

REDUCTION OF GAS VOLUME

Values of (1+at) for Temperatures from 0 to 120° C.

T	0	1	2	3	4	5	6	7	8	9
00	1.0000	1.0037	1.0073	1.0110	1.0147	1.0183	1.0220	1.0257	1.0294	1.0330
10	1.0367	1.0404	1.0440	1.0477	1.0514	1.0550	1.0587	1.0624	1.0661	1.0697
20	1.0734	1.0771	1.0807	1.0844	1.0881	1.0917	1.0954	1.0991	1.1028	1.1064
30	1.1101	1.1138	1.1174	1.1211	1.1248	1.1284	1.1321	1.1358	1.1395	1.1431
40	1.1468	1.1505	1.1541	1.1578	1.1615	1.1651	1.1688	1.1725	1.1762	1.1798
50	1.1835	1.1872	1.1908	1.1945	1.1982	1.2018	1.2055	1.2092	1.2129	1.2165
60	1.2202	1.2239	1.2275	1.2312	1.2349	1.2385	1.2422	1.2459	1.2496	1.2532
70	1.2569	1.2606	1.2642	1.2679	1.2716	1.2752	1.2789	1.2826	1.2863	1.2899
80	1.2936	1.2973	1.3009	1.3046	1.3083	1.3119	1.3156	1.3193	1.3230	1.3266
90	1.3303	1.3340	1.3376	1.3413	1.3450	1.3486	1.3523	1.3560	1.3597	1.3633
100	1.3670	1.3707	1.3743	1.3780	1.3817	1.3853	1.3890	1.3927	1.3964	1.4000
110	1.4037	1.4074	1.4110	1.4147	1.4184	1.4220	1.4257	1.4294	1.4331	1.4367
120	1.4404									

Values of H/760 for Pressures from 700 to 780 mm. of Mercury.

H	0	1	2	3	4	5	6	7	8	9
700	0.9211	0.9224	0.9237	0.9250	0.9263	0.9276	0.9289	0.9303	0.9316	0.9329
710	0.9342	0.9355	0.9368	0.9382	0.9395	0.9408	0.9421	0.9434	0.9447	0.9461
720	0.9474	0.9487	0.9500	0.9513	0.9526	0.9539	0.9553	0.9566	0.9579	0.9592
730	0.9605	0.9618	0.9632	0.9645	0.9658	0.9671	0.9684	0.9697	0.9711	0.9724
740	0.9737	0.9750	0.9763	0.9776	0.9789	0.9803	0.9816	0.9829	0.9842	0.9855
750	0.9868	0.9882	0.9895	0.9908	0.9921	0.9934	0.9947	0.9961	0.9974	0.9987
760	1.0000	1.0013	1.0026	1.0039	1.0053	1.0066	1.0079	1.0092	1.0105	1.0118
770	1.0132	1.0145	1.0158	1.0171	1.0184	1.0197	1.0211	1.0224	1.0237	1.0250
780	1.0263									

SPECIFIC HEAT OF WATER AND MERCURY

Values for water from 0–100° C. are the mean of various determinations including Calendar and Blonsfield, 1912; above 100, Regnault's values recomputed by Guillaume, 1912.

Values for mercury 0–80° C. due to Barnes and Cooke; 90–140°, mean of Winkelmann, Naccari and Milthaler; above 140°, mean of Naccari and Milthaler.

Specific heat in normal calories (15° C.).

Temp. ° C.	Water.	Mercury.	Temp. ° C.	Water.	Mercury.
0	1.00874	.03346	80	1.00239	.03284
5	1.00477	.03340	85	1.00329	
10	1.00184	.03335	90	1.00433	.03277
15	1.00000	.03330	95	1.00534	
20	0.99859	.03325	100	1.00645	.03269
25	0.99765	.03320	110	1.0116	.03262
30	0.99745	.03316	120	1.0144	.03255
35	0.99743	.03312	130	1.0174	.03248
40	0.99761	.03308	140	1.0206	.03241
45	0.99790		150	1.0240	.0324
50	0.99829	.03300	160	1.0275	
55	0.99873		170	1.0313	.0322
60	0.99934	.03294	180	1.0353	
65	1.00001		190	1.0395	.0320
70	1.00077	.03289	200	1.0439	
75	1.00158				

SPECIFIC HEAT OF CHEMICAL ELEMENTS

Values given in calories per gram

(Principally from Smithsonian Tables.)

Element.	Temp. ° C.	Sp. heat.	Observer.
Aluminum	−233	0.0165	Nernst, 1911
Aluminum	250	.2382	Bontschew
Aluminum	500	.2739	Bontschew
Aluminum	17–100	.217	Schimpf, 1910
Antimony	15	.0489	Naccari, 1887–88
Antimony	100	.0503	Naccari, 1887–88
Antimony	200	.0520	Naccari, 1887–88
Arsenic, gray	0–100	.0822	Wigand, 1907
black	0–100	.0861	Wigand, 1907
Bismuth	0	.0301	Lorenz, 1881
Bismuth	75	.0309	Lorenz, 1881
Bismuth	20–100	.0302	Stücker, 1905
Bromine fluid	13–45	.107	Andrews, 1848 [1910
Cadmium	−188–+20	.0514	Richards & Jackson,
Cadmium	0–100	.0560	Kahlbaum & Roth, 1902
Cadmium	21	.0551	Naccari, 1887–88
Calcium	0–157	.1520	Bernini, 1907
Calcium	0–181	.170	Bunsen, 1887
Carbon graphite	+11	.160	Weber, 1875
Carbon graphite	977	.467	Weber, 1875
Carbon diamond	+11	.113	Weber, 1875
Carbon diamond	985	.459	Weber, 1875
Chromium	100	.1121	Adler, 1903
Cobalt	15–100	.1030	Tilden, 1903
Copper	−253	.0031	Nernst, 1911
Copper	−213	.029	Nernst, 1911
Copper	−173	.059	Nernst, 1911
Copper	20	.0912	Gaede, 1902
Copper	100	.0942	Naccari, 1887–88
Copper	200	.0963	Naccari, 1887–88
Copper	15–100	.0931	Bartoli & Stracciati 1895
Gold	−185–+20	.033	Nordmeyer-Bernouli, 1907, 1908
Gold	0–100	.0316	Violle, 1887, 1878
Iridium	18–100	.0323	Behn, 1898, 1900
Iron, cast	20–100	.1189	Schmitz, 1903
wrought	15–100	.1152	Nichol, 1881
hard drawn	20–100	.1146	Hill, 1901
Lead	15	.0299	Naccari, 1887–88
Lead	100	.0311	Naccari, 1887–88
Lead	18–100	.03096	Magnus, 1910
Lithium	50	.9063	Laemmel, 1905
Magnesium	20–100	.2492	Stücker, 1905
Manganese	0	.1072	Laemmel, 1905
Mercury	0	.03346	Barnes-Cooke, 1903
Nickel	18–100	.109	Behn, 1898–1900

SPECIFIC HEAT OF CHEMICAL ELEMENTS (Cont.)

Values given in calories per gram.

Element.	Temp. ° C.	Sp. heat.	Observer.
Phosphorus, red...	0–51	0.1829	Wiegand, 1906
yellow.........	13–36	.202	Wiegand, 1906
Platinum.........	−186–+18	.0293	Behn, 1898–1900
Platinum.........	0–100	.0323	Violle, 1878
Platinum.........	500	.0356	White, 1909
Rhodium.........	10–97	.0580	Regnault, 1840–1861
Silver............	0–100	.0559	Bunsen, 1870–1887
Silver............	500	.0581	Tilden, 1900–1903
Sulphur, rhombic..	0–54	.1728	Wiegand, 1906
monoclinic......	0–52	.1809	Wiegand, 1906
Tin, cast.........	21–109	.0551	Spring, 1886–1895
Titanium.........	0–100	.1125	Nilson-Pettersson, 1887
Tungsten.........	0–100	.0336	Mache, 1897
Uranium.........	0–98	.028	Blümcke, 1885
Vanadium........	0–100	.1153	Mache, 1897
Zinc.............	0–100	.0935	Bunsen, 1870–1887
Zinc.............	300	.1040	Naccari, 1887–88

BOILING-POINT OF WATER*

(Hydrogen Scale)

Pressure mm.	Tenths of millimeters .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
700	97.714	718	722	725	729	733	737	741	745	749
701	753	757	761	765	769	773	777	781	785	789
702	792	796	800	804	808	812	816	820	824	828
703	832	836	840	844	847	851	855	859	863	867
704	871	875	879	883	887	891	895	899	902	906
705	97.910	914	918	922	926	930	934	938	942	946
706	949	953	957	961	965	969	973	977	981	985
707	989	993	996	*000	*004	*008	*012	*016	*020	*024
708	98.028	032	036	040	043	047	051	055	059	063
709	067	071	075	079	082	086	090	094	098	102
710	98.106	110	114	118	121	125	129	133	137	141
711	145	149	153	157	160	164	168	172	176	180
712	184	188	192	195	199	203	207	211	215	219
713	223	227	230	234	238	242	246	250	254	258
714	261	265	269	273	277	281	285	289	292	296
715	98.300	304	308	312	316	320	323	327	331	335
716	339	343	347	351	355	358	362	366	370	374
717	378	382	385	389	393	397	401	405	409	412
718	416	420	424	428	432	436	440	443	447	451
719	455	459	463	467	470	474	478	482	486	490
720	98.493	497	501	505	509	513	517	520	524	528
721	532	536	540	544	547	551	555	559	563	567
722	570	574	578	582	586	590	593	597	601	605
723	609	613	617	620	624	628	632	636	640	643
724	647	651	655	659	662	666	670	674	678	682
725	98.686	689	693	697	701	705	709	712	716	720
726	724	728	732	735	739	743	747	751	755	758
727	762	766	770	774	777	781	785	789	793	797
728	800	804	808	812	816	819	823	827	831	835
729	838	842	846	850	854	858	861	865	869	873
730	98.877	880	884	888	892	896	899	903	907	911
731	915	918	922	926	930	934	937	941	945	949
732	953	956	960	964	968	972	975	979	983	987
733	991	994	998	*002	*006	*010	*013	*017	*021	*025
734	99.029	032	036	040	044	048	051	055	059	063
735	99.067	070	074	078	082	085	089	093	097	101
736	104	108	112	116	119	123	127	131	135	138
737	142	146	150	153	157	161	165	169	172	176
738	180	184	187	191	195	199	203	206	210	214
739	218	221	225	229	233	236	240	244	248	252
740	99.255	259	263	267	270	274	278	282	285	289
741	293	297	300	304	308	312	316	319	323	327
742	331	334	338	342	346	349	353	357	361	364
743	368	372	376	379	383	387	391	394	398	402
744	406	409	413	417	421	424	428	432	436	439
745	99.443	447	451	454	458	462	466	469	473	477
746	481	484	488	492	495	499	503	507	510	514
747	518	522	525	529	533	537	540	544	548	551
748	555	559	563	566	570	574	578	581	585	589
749	592	596	600	604	607	611	615	619	622	626

* See also under Vapor Tension.

BOILING-POINT OF WATER (Continued)

(Hydrogen Scale)

Pressure mm.	Tenths of millimeters									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
750	99.630	633	637	641	645	648	652	656	659	663
751	667	671	674	678	682	686	689	693	697	700
752	704	708	712	715	719	723	726	730	734	738
753	741	745	749	752	756	760	764	767	771	775
754	778	782	786	790	793	797	801	804	808	812
755	99.815	819	823	827	830	834	838	841	845	849
756	852	856	860	863	867	871	875	878	882	886
757	889	893	897	900	904	908	911	915	919	923
758	926	930	934	937	941	945	948	952	956	959
759	963	967	970	974	978	982	985	989	993	996
760	100.000	004	007	011	015	018	022	026	029	033
761	037	040	044	048	052	055	059	063	066	070
762	074	077	081	085	088	092	096	099	103	107
763	110	114	118	121	125	129	132	136	140	143
764	147	151	154	158	162	165	169	173	176	180
765	100.184	187	191	195	198	202	206	209	213	216
766	220	224	227	231	235	238	242	246	249	253
767	257	260	264	268	271	275	279	283	286	290
768	293	297	300	304	308	311	315	319	322	326
769	330	333	337	341	344	348	352	355	359	363
770	100.366	370	373	377	381	384	388	392	395	399
771	403	406	410	414	417	421	424	428	432	435
772	439	442	446	450	453	457	461	464	468	472
773	475	479	483	486	490	493	497	501	504	508
774	511	515	519	522	526	530	533	537	540	544
775	100.548	551	555	559	562	566	569	573	577	580
776	584	588	591	595	598	602	606	609	613	616
777	620	624	627	631	634	638	642	645	649	653
778	656	660	663	667	671	674	678	681	685	689
779	692	696	689	703	707	710	714	718	721	725
780	100.728	732	735	739	743	746	750	753	757	761
781	764	768	772	775	779	782	786	789	793	797
782	800	804	807	811	815	818	822	825	829	833
783	836	840	843	847	851	854	858	861	865	869
784	872	876	879	883	886	890	894	897	901	904
785	100.908	912	915	919	922	926	929	933	937	940
786	944	947	951	954	958	962	965	969	972	976
787	979	983	987	990	994	997	*001	*005	*008	*012
788	101.015	019	022	026	029	033	037	040	044	047
789	051	054	058	062	065	069	072	076	079	083
790	101.087	090	094	097	101	104	108	112	115	119
791	122	126	129	133	136	140	144	147	151	154
792	158	161	165	168	172	176	179	183	186	190
793	193	197	200	204	207	211	215	218	222	225
794	229	232	236	239	243	246	250	254	257	261
795	101.264	268	271	275	278	282	286	289	293	296
796	300	303	307	310	314	317	321	324	328	332
797	335	339	342	346	349	353	356	360	363	367
798	370	374	377	381	385	388	392	395	399	402
799	406	409	413	416	420	423	427	430	434	437
800	101.441	...	...	...	.....	...	...	...	...	...

SPECIFIC HEAT OF VARIOUS SOLIDS

Values given in calories per gram.

Substance.	Temp. ° C.	Sp. heat.	Observer.
Alloys, bell metal. .	15–98	0.0858	Regnault
brass, red.	0	.08991	Lorenz
brass, yellow. . . .	0	.08831	Lorenz
German silver. . .	0–100	.09464	Tomlinson
Asbestos.	20–98	.195	Ulrich
Basalt.	20–100	.20	Mean
Calcspar.	0–100	.2005	Lindner
Carborundum.	3–44	.162	
Cellulose, dry.	. . . .	.37	Mean
Cement, powder. . .	200–10	.20	
Chalk.	20–99	.214	Regnault
Charcoal.	10	.16	Weber, 1875
Clay, dry.	20–100	.22	Mean
Ebonite.	20–100	.40	Louguinine, 1882
Glass, normal thermometer.	19–100	.1988	Wachsmuth
crown.	10–50	.161	KH. Meyer
flint.	10–50	.117	H. Meyer
Granite.	12–100	.192	Joly
Ice.	−200	.168	Nernst, 1910
	−180	.199	Nernst, 1910
	−160	.230	Nernst, 1910
	−140	.262	Nernst, 1910
	−100	.325	Nernst, 1910
	− 60	.392	Nernst, 1910
	− 20	.480	Nernst, 1910
	− 10	.530	Nernst, 1910
India rubber (Para)	?–100	.481	Gee and Terry
Leather, dry.	. . . .	.36	
Marble.	0–100	.21	
Mica (Mg).	20–98	.2061	Ulrich
Paraffin.	0–20	.6939	R. W. Weber
Porcelain.	15–950	.26	Harker, 1905
Quartz.	12–100	.188	Joly
Rock-salt.	13–45	.219	Kopp
Sugar.	20	.274	Hess, 1888
Vulcanite.	20–100	.3312	A. M. Mayer
Wood.	. . . . . .	.42	

SPECIFIC HEAT OF VARIOUS LIQUIDS

Liquid.	Temp. ° C.	Sp. heat.	Observer.
Acetic acid	20	0.472	Schiff, 1886
Acetone	0	.506	Regnault, 1862
Alcohol, ethyl	0	.548	Regnault
ethyl	40	.648	Regnault
methyl	5–10	.590	Regnault
methyl	15–20	.601	Regnault
Amyl acetate	20	.459	Schiff, 1880
Benzol, C^6H^6	10	.340	de Heen & Deruyts
Benzol	40	.423	de Heen & Deruyts
Carbon bisulphide	30	.240	Regnault
Chloroform	0	.232	Regnault
Ethyl ether	0	.529	Regnault
Glycerine	15–50	.576	Emo
Oils, olive	6.6	.471	
turpentine	0	.411	Regnault
Petroleum	21–58	.511	Pagliani

SPECIFIC HEAT AQUEOUS SOLUTIONS

Approximate Values

Substance.	Parts by weight in 100 parts of solution.		
	5	10	20
Acid, hydrochloric	.93	.85	
nitric	.95	.90	.82
sulphuric	.95	.92	.84
Alcohol, ethyl	1.02	1.03	1.05
Ammonia	.998	.99	
Carbonate sodium	.93	.89	
Chloride calcium	.94		
sodium	.94	.89	.81
Hydrate potassium	.93	.87	
sodium	.94	.91	.86
Sugar	.97	.94	.89

SPECIFIC HEAT OF GASES

Giving the specific heat of gases at constant pressure in calories per gram and the ratio of the specific heat at constant pressure to that at constant volume.

Values are for atmospheric pressure.
(Selected from Smithsonian Tables.)

Gas or vapor.	Specific heat at constant pressure.			Ratio of specific heats.		
	Temp. ° C.	Sp. ht.	Obs.*	Temp. ° C.	Ratio Cp/Cv	Obs.*
Acetone	26–110	0.3468	W			
Air	0–100	0.2374	R			
Air	0–200	0.2375	R			
Air	20–630	0.2429	A			
Alcohol	108–220	0.4534	R	53	1.133	J
Ammonia	23–100	0.5202	W	0	1.3172	Wr
Argon	20–90	0.1233	D	0	1.667	N
Benzol	34–115	0.2990	W	20	1.403	P
Bromine	83–228	0.0555	R	20–388	1.293	S
Carbon dioxide	15–100	0.2025	R			
Carbon monoxide	23–99	0.2425	W	0	1.403	Wr
Carbon disluphide	86–190	0.1596	R	3.67	1.205	B
Chlorine	13–202	0.1241	R	20–340	1.323	S
Chloroform	27–118	0.1441	W	22–78	1.102	B
Ether	25–111	0.4280	W	12–20	1.024	L
Hydrochloric acid	13–100	0.1940	S	20	1.389	S
Hydrogen	12–198	3.4090	R			
Hydrogen sulphide	20–206	0.2451	R	10–40	1.276	Mr
Methane	18–208	0.5929	R	11–30	1.316	Mr
Nitrogen	0–200	0.2438	R	....	1.41	C
Nitric oxide	13–172	0.2317	R			
Nitrous oxide	16–207	0.2262	R	0	1.311	Wr
Oxygen	13–207	0.2175	R	5–14	1.3977	L–P
Sulphur dioxide	16–202	0.1544	R	16–34	1.256	Mr
Water vapor	0	0.4655	T	78	1.274	B
Water vapor	100	0.421	T	94	1.33	J
Water vapor	180	0.51	T			

*A Austin
B Beyme
C Cazin
D Dittenberger
J Jaeger
L Low
L–P Lummer & Pringsheim
Mr Muller
N Niemeyer
P Pagliani
R Regnault
S Strecker
T Thiesen
W Wiedemann
Wr Wüllner

MELTING AND BOILING TEMPERATURES

Temperature of Fusion for Various Substances for Atmospheric Pressure

For the melting- and boiling-points of the chemical elements and of inorganic compounds, see under Physical Constants of the Elements, page 15, and Physical Constants of Inorganic Compounds, page 21.

Substance.	Temp. of fusion ° C.	Substance.	Temp. of fusion ° C.
Acetylene.	−81	German silver. .	1000.
Alcohol, ethyl. .	−130.	Glass.	1100.
Brass.	900.	Glycerine.	20.
Butter.	31–31.5	Olive oil.	2–6
Camphor.	177.7	Paraffin.	55.
Caoutchouc, pure gum. . . .	120.	Resin.	135.
Chloroform. . . .	−63.2	Sea water.	−2.5
Ether.	−117.6	Sugar (cane). . .	160.

Boiling-point for Various Substances

Giving the boiling-point at atmospheric pressure and the variation per cm. pressure near 76 cm.

Substance.	Temp. ° C.	Variation.
Acetone.	57.	0.39
Acetylene.	−72.2	
Alcohol, ethyl.	78.3	0.34
methyl.	64.7	0.35
Amyl acetate.	148.	
Benzene.	80.	0.43
Camphor.	205.	0.56
Chloroform.	61.2	0.41
Ether.	34.6	0.40
Gasoline.	70–90.	
Glycerine.	291.	
Turpentine.	159.	

MELTING POINT OF ICE—VARIATION WITH PRESSURE

(From Tamann, 1900, by permission.)

Pressure in kg. per sq.cm.	Temp. ° C.	Pressure in kg. per sq.cm.	Temp. ° C.
1	0.0	1410	−12.5
336	− 2.5	1625	−15.0
615	− 5.0	1835	−17.5
890	− 7.5	2042	−20.0
1155	−10.0	2200	−22.1

CRITICAL TEMPERATURE AND PRESSURE AND OTHER CONSTANTS OF GASES

Freezing Point, Boiling Point (76 cm.), and Critical Data, Van der Waal's Constants (for 1 gr.)

Gas.	FREEZING PT. °C.	LAT. HT. OF FUS.	BOIL. PT. °C.	LAT. HT. OF VAP. AT BOIL. PT.	DENS. AT BOIL. PT.	CRIT. TEMP. °C.	CRIT. PRES. (ATM.)	CRIT. DENS.	a	b
Hydrogen	−260.0	16.0	−252.5	200.0	0.070	−240.8	13.4–15		5160	9.28
Oxygen	−227.0 (9 mm.)		−181.5	52.0	1.135	−118.0	50.0	0.65	1320	0.98
Nitrogen	−210.0 (94 mm.)		−194.0	48.0	0.790	−145.0	34.0	0.37	1700	1.40
Air			−191.0			−142.0	37.8			
Argon	−188.0		−186.0		1.212	−117.0	52.0		810	0.77
Helium			−268.8			−268.0	2–3.0	0.15		
Sulphur dioxide			−10.0	82.0	1.460	155.0	78.9	0.55	1610	0.87
Chlorine	−102.0		−33.6	67.0		146.0	93.5			
Ammonia	−75.0	108.0	−33.5	295.0		131.0	113.0		13800	2.11
Nitrogen peroxide			22.5	93.0		171.2				
Carbon dioxide			−78.2			31.0	77.0	0.29	1857	0.971
Ethylene			−103.0			10.0	38.0	0.22		
Acetylene						36.5	61.6	0.31	5930	1.80
Water	0.0	80.0	100.0	537.0		364.0	195.0	0.43	18000	1.84
Acetic acid	17.0	43.7	118.0	85.0		321.0	57.0	0.351	4884	1.78
Ethyl alcohol			78.3	201.5		240.0	64.0	0.228	5700	1.834
Benzol	5.4	30.2	80.2	93.0		288.0				
Acetone			56.4	125.3		238.0	52.0			
Carbon bisulphide			46.0	83.8		277.0	78.0	0.354		
Ether			38.0	90.0		190.0	37.0	0.246	3180	1.82
Chloroform			60.1	59.0		260.0	55.0			

FREEZING MIXTURES

A is the proportion of the substance named in the first column to be added to the proportion of the substance given in column *B*. The table gives the temperature of the separate ingredients and the temperature attained by the mixture.

(From Smithsonian Tables.)

Substance.	*A*	*B*	Initial Temp. ° C.	Temp. ° C. attained by mixt.
$NaC_2H_3O_2$ (cryst.)	85	H_2O 100	10.7	− 4.7
NH_4Cl	30	H_2O 100	13.3	− 5.1
$NaNO_3$	75	H_2O 100	13.2	− 5.3
$Na_2S_2O_3$ (cryst.)	110	H_2O 100	10.7	− 8.0
KI	140	H_2O 100	10.8	−11.7
$CaCl_2$ (cryst.)	250	H_2O 100	10.8	−12.4
NH_4NO_3	60	H_2O 100	13.6	−13.6
$CaCl_2$	30	* Snow 100	− 1	−10.9
NH_4Cl	25	Snow 100	− 1	−15.4
NH_4NO_3	45	Snow 100	− 1	−16.75
$NaNO_3$	50	Snow 100	− 1	−17.75
NaCl	33	Snow 100	− 1	−21.3
$H_2SO_4+H_2O$ (66.1% H_2SO_4)	1	Snow 1.097	− 1	−37.0
	1	Snow 2.52	− 1	−30.0
	1	Snow 4.32	− 1	−25.0
	1	Snow 7.92	− 1	−20.0
	1	Snow 13.08	− 1	−16.0
$CaCl_2+6H_2O$	1	Snow .49	0	−19.7
	1	Snow .61	0	−39.0
	1	Snow .70	0	−54.9
	1	Snow .81	0	−40.3
	1	Snow 1.23	0	−21.5
	1	Snow 2.46	0	− 9.0
	1	Snow 4.92	0	− 4.0
Alcohol at 4°	77	Snow 73.	0	−30.0
	..	CO_2 solid	......	−72.0
Chloroform	....	CO_2 solid	......	−77.0
Ether	....	CO_2 solid	......	−77.0
Liquid SO_2	....	CO_2 solid	......	−82.0
NH_4NO_3	1	H_2O .94	20	− 4.0
	1	Snow .94	0	− 4.0
	1	H_2O 1.20	10	−14.0
	1	Snow 1.20	0	−14.0
	1	H_2O 1.31	10	−17.5
	1	Snow 1.31	0	−17.5

* Or finely pulverized ice.

HEAT EQUIVALENT OF FUSION

The table gives the heat equivalent in calories per gram at the temperature of fusion.

(From Smithsonian Tables.)

Substance.	Temp. ° C.	Heat cal/g.	Observer.
Aluminum	658.	76.8	Glaser
Ammonia	−75.	108.	Massol
Benzole	5.4	30.6	Mean
Bromine	−7.3	16.2	Regnault
Bismuth	268.	12.64	Person
Cadmium	320.7	13.66	Person
Calcium chloride	28.5	40.7	Person
Copper	1083	42.	Mean
Iron, gray cast	....	23.	Grumer
white cast	....	33.	Grumer
slag	....	50.	Grumer
Iodine	....	11.71	Favre & Silbermann
Ice	0	79.24	Regnault
Ice	0	80.02	Bunsen
Ice from sea water	−8.7	54.0	Petterson
Lead	327	5.86	Rudberg
Mercury	−39	2.82	Person
Naphthalene	79.87	35.62	Pickering
Nickel	1435	4.64	Pionchon
Palladium	1545	36.3	Violle
Phosphorus	44.2	4.97	Petterson
Platinum	1755	27.2	Violle
Potassium	62	15.7	Joannis
Potassium nitrate	333.5	48.9	Person
Phenol	25.37	24.93	Petterson
Paraffin	52.40	35.10	Batelli
Silver	961	21.07	Person
Sodium	97	31.7	Joannis
Sodium nitrate	305.8	64.87	Joannis
phosphate	36.1	66.8	Joannis
Spermaceti	43.9	36.98	Batelli
Sulphur	115	9.37	Person
Tin	232	14.0	Mean
Wax (Bees')	61.8	42.3	Mean
Zinc	419	28.13	Mean

HEAT EQUIVALENT OF VAPORIZATION

The table gives the heat equivalent (or latent heat) of vaporization in calories per gram, at the temperature of ebullition, and at the pressure of the vapor for that temperature.

(Principally from the Smithsonian Tables.)

Substance.	Temp. °C.	Heat Cal/g.	Observer.
Acetic acid	118*	84.9	Ogier
Air	....	50.97	Fenner-Richtmyer
Alcohol: amyl	131*	120	Schall
ethyl	78.1*	205	Wirtz
ethyl	0	236	Regnault
methyl	64.5*	2.67	Wirtz
methyl	0	289	Ramsay & Young
Ammonia	7.8	294.2	Regnault
Ammonia	11	291.3	Regnault
Ammonia	16	297.4	Regnault
Ammonia	17	296.5	Regnault
Benzene	80.1*	92.9	Wirtz
Bromine	61*	45.6	Andrews
Carbon dioxide, liq	− 25	72.23	Cailletet & Mathias
Carbon dioxide, liq	0	57.48	Cailletet & Mathias
Carbon dioxide, liq	12.35	44.97	Mathias
Carbon dioxide, liq	22.04	31.8	Mathias
Carbon dioxide, liq	29.85	14.4	Mathias
Carbon dioxide, liq	30.82	3.72	Mathias
Carbon disulphide	46.1*	83.8	Wirtz
Carbon disulphide	0	90	Regnault
Chloroform	60.9*	58.5	Wirtz
Ether	34.5*	88.4	Wirtz
Ether	34.9	90.5	Andrews
Ether	0	94	Regnault
Iodine	184*	23.95	Favre & Silbermann
Mercury	357*	65	Mean
Nitrogen	−195.6*	47.65	Alt
Oxygen	−182.9*	50.97	Alt
Sulphur dioxide	0	91.2	Cailletet & Mathias
Sulphur dioxide	30	80.5	Cailletet & Mathias
Sulphur dioxide	65	68.4	Cailletet & Mathias
Turpentine	159.3	74.04	Brix
Water	100	535.9	Andrews
Water	0	596.8	Dieterici, 1889
Water	20	585.3	Smith, 1908
Water	40	574.0	Henning, 1909
Water	60	562.9	Henning, 1909
Water	80	551.1	Henning, 1909
Water	100*	538.7	Henning, 1909
Water	120	525.3	Henning, 1909
Water	140	510.9	Henning, 1909
Water	160	496.6	Henning, 1909
Water	180	482.2	Henning, 1909

Temperature values marked * are those of normal ebullition, at 76 cm. pressure.

CHANGE IN VOLUME DUE TO FUSION

The table gives the variation in volume expressed in c.cm. for one gram of the substance.

Substance.	Variation, cm.	Observer.
Aluminum	+0.019	Toepler, 1894
Bismuth	−0.0034	Toepler, 1894
Cadmium	+0.0064	Toepler, 1894
Iron	−0.0085	Wrightson, Roberts, 1881
Lead	+0.0034	Toepler, 1894
Tin	+0.0039	Toepler, 1894
Water	−0.083*	Toepler, 1894
Zinc	+0.0105	Toepler, 1894

*For one cubic centimeter.

FIXED POINTS FOR HIGH TEMPERATURES

Temperatures are for 76 cm. pressure.

Substance.	Boiling-point ° C.	Variation per cm. pressure, ° C.
Alcohol, ethyl	78.26	0.34
Aniline	184.	0.51
Benzene	80.	0.43
Chloro benzene	132.	0.50
Diphenylamine	302.	
Mercury	356.	
Naphthaline	218.	0.59
Sulphur	445.2	
Toluidine, *o*	199.7	0.58
Toulene	109.2	0.45
Water	100.	0.37
Xylene, *m*	138.8	0.50
Zinc	930.	

Substance.	Melting point ° C.	Substance.	Melting point ° C.
Aluminum	657	Platinum	1775
Copper	1084	Sodium chloride	800
Gold	1064	Tin	232
Nickel	1427	Zinc	419

VAPOR TENSION OF WATER

Tension of Aqueous Vapor, −30 to 0° C., Over Water

The tension is given in millimeters of mercury at 0° C.

(From International Bureau of Weights and Measures.)

Temp. ° C.	0.0	0.2	0.4	0.6	0.8
−30	0.3805				
−29	0.4185	0.4106	0.4028	0.3952	0.3878
−28	0.4598	0.4512	0.4428	0.4346	0.4265
−27	0.5047	0.4954	0.4862	0.4772	0.4684
−26	0.5535	0.5433	0.5333	0.5236	0.5141
−25	0.6064	0.5955	0.5847	0.5741	0.5637
−24	0.6637	0.6518	0.6402	0.6288	0.6175
−23	0.7258	0.7130	0.7003	0.6879	0.6757
−22	0.7930	0.7792	0.7655	0.7520	0.7388
−21	0.8656	0.8506	0.8359	0.8214	0.8071
−20	0.9441	0.9279	0.9120	0.8963	0.8808
−19	1.0288	1.0114	0.9941	0.9772	0.9605
−18	1.1202	1.1013	1.0828	1.0646	1.0465
−17	1.2187	1.1985	1.1785	1.1588	1.1394
−16	1.3248	1.3030	1.2814	1.2602	1.2393
−15	1.4390	1.4155	1.3924	1.3695	1.3470
−14	1.5618	1.5366	1.5117	1.4872	1.4629
−13	1.6939	1.6667	1.6399	1.6135	1.5874
−12	1.8357	1.8065	1.7776	1.7493	1.7214
−11	1.9880	1.9567	1.9258	1.8953	1.8653
−10	2.1514	2.1178	2.0847	2.0520	2.0198
− 9	2.3266	2.2905	2.2550	2.2199	2.1854
− 8	2.5143	2.4758	2.4378	2.4002	2.3632
− 7	2.7153	2.6740	2.6332	2.5930	2.5534
− 6	2.9304	2.8863	2.8427	2.7997	2.7572
− 5	3.1605	3.1132	3.0665	3.0205	2.9751
− 4	3.4065	3.3560	3.3062	3.2570	3.2084
− 3	3.6693	3.6153	3.5620	3.5095	3.4576
− 2	3.9499	3.8923	3.8355	3.7794	3.7240
− 1	4.2493	4.1878	4.1271	4.0672	4.0082
− 0	4.5687	4.5032	4.4385	4.3747	4.3116

VAPOR TENSION OF WATER

Tension of Aqueous Vapor. 40 to 0° C., Over Ice

The tension is given in millimeters of mercury,
(Juhlin and Marvin.)

Temp. ° C.	0.	1.	2.	3.	4.
−40	0.105	0.095	0.085	0.076	0.068
−30	0.292	0.264	0.238	0.215	0.193
−20	0.787	0.714	0.648	0.589	0.534
−10	1.974	1.806	1.650	1.506	1.375

Temp. ° C.	5.	6.	7.	8.	9.
−40	0.061	0.054	0.048	0.043	0.038
−30	0.173	0.156	0.141	0.127	0.115
−20	0.484	0.438	0.397	0.358	0.324
−10	1.257	1.148	1.048	0.955	0.868

Temp. ° C.	.0	.1	.2	3	.4
−10	1.974	1.956	1.939	1.922	1.905
− 9	2.154	2.136	2.118	2.100	2.082
− 8	2.347	2.327	2.307	2.287	2.268
− 7	2.557	2.535	2.514	2.492	2.470
− 6	2.785	2.761	2.738	2.715	2.692
− 5	3.032	3.006	2.981	2.956	2.931
− 4	3.299	3.271	3.244	3.217	3.190
− 3	3.586	3.556	3.527	3.498	3.469
− 2	3.894	3.862	3.831	3.799	3.768
− 1	4.223	4.189	4.155	4.122	4.089
− 0	4.579	4.543	4.507	4.470	4.434

Temp. ° C.	.5	.6	.7	.8	.9
−10	1.888	1.872	1.855	1.838	1.822
− 9	2.064	2.046	2.028	2.010	1.992
− 8	2.249	2.230	2.211	2.192	2.173
− 7	2.449	2.428	2.407	2.387	2.367
− 6	2.669	2.646	2.624	2.601	2.579
− 5	2.906	2.882	2.857	2.833	2.809
− 4	3.163	3.136	3.110	3.084	3.058
− 3	3.440	3.411	3.382	3.354	3.326
− 2	3.737	3.706	3.676	3.646	3.616
− 1	4.056	4.023	3.990	3.958	3.926
− 0	4.398	4.362	4.327	4.292	4.257

VAPOR TENSION OF WATER

Tension of Aqueous Vapor, 0 to 100° C.

The tension is given in millimeters of mercury at 0° C.

(International Bureau of Weights and Measures.)

Temp. ° C.	0.0	0.2	0.4	0.6	0.8
0	4.5687	4.6350	4.7022	4.7703	4.8393
1	4.9091	4.9798	5.0515	5.1240	5.1975
2	5.2719	5.3472	5.4235	5.5008	5.5790
3	5.6582	5.7383	5.8195	5.9017	5.9850
4	6.0693	6.1546	6.2410	6.3285	6.4171
5	6.5067	6.5974	6.6893	6.7824	6.8765
6	6.9718	7.0682	7.1658	7.2646	7.3647
7	7.4660	7.5685	7.6722	7.7772	7.8834
8	7.9909	8.0998	8.2099	8.3214	8.4342
9	8.5484	8.6641	8.7810	8.8993	9.0189
10	9.1398	9.2623	9.3863	9.5117	9.6387
11	9.7671	9.8969	10.028	10.161	10.296
12	10.432	10.570	10.709	10.850	10.993
13	11.137	11.283	11.430	11.580	11.731
14	11.884	12.038	12.194	12.352	12.512
15	12.674	12.837	13.003	13.170	13.339
16	13.510	13.683	13.858	14.035	14.214
17	14.395	14.578	14.763	14.950	15.139
18	15.330	15.524	15.719	15.917	16.117
19	16.319	16.523	16.730	16.939	17.150
20	17.363	17.579	17.997	18.018	18.241
21	18.466	18.694	18.924	19.157	19.392
22	19.630	19.870	20.113	20.359	20.607
23	20.858	21.111	21.367	21.626	21.888
24	22.152	22.420	22.690	22.963	23.239
25	23.517	23.799	24.084	24.371	24.662
26	24.956	25.252	25.552	25.855	26.161
27	26.471	26.783	27.099	27.418	27.740
28	28.065	28.394	28.727	29.062	29.401
29	29.744	30.090	30.440	30.793	31.149
30	31.510	31.873	32.341	32.612	32.988
31	33.366	33.749	34.136	34.526	34.920
32	35.318	35.720	36.126	36.536	36.951
33	37.369	37.791	38.218	38.649	39.084
34	39.523	39.966	40.414	40.866	41.323

VAPOR TENSION OF WATER (Continued)

TENSION OF AQUEOUS VAPOR, 0 TO 100° C.

In millimeters of mercury.

Temp. ° C.	0.0	0.2	0.4	0.6	0.8
35	41.784	42.250	42.720	43.195	43.674
36	44.158	44.646	45.139	45.637	46.140
37	46.648	47.160	47.677	48.200	48.727
38	49.259	49.796	50.339	50.886	51.439
39	51.997	52.560	53.128	53.702	54.281
40	54.865	55.455	56.051	56.652	57.258
41	57.870	58.488	59.111	59.741	60.376
42	61.017	61.664	62.316	62.975	63.640
43	64.310	64.987	65.670	56.359	67.055
44	67.757	68.465	69.180	69.901	70.628
45	71.362	72.102	72.850	73.603	74.364
46	75.131	75.906	76.687	77.475	78.270
47	79.071	79.880	80.696	81.520	82.350
48	83.188	84.034	84.886	85.746	86.614
49	87.488	88.371	89.261	90.159	91.064
50	91.978	92.900	93.829	94.766	95.711
51	96.664	97.626	98.595	99.573	100.56
52	101.55	102.56	103.57	104.59	105.62
53	106.65	107.70	108.76	109.82	110.89
54	111.97	113.06	114.16	115.27	116.39
55	117.52	118.65	119.80	120.95	122.12
56	123.29	124.48	125.67	126.87	128.09
57	129.31	130.54	131.79	133.04	134.30
58	135.58	136.86	138.15	139.46	140.77
59	142.10	143.43	144.78	146.14	147.51
60	148.88	150.27	151.68	153.09	154.51
61	155.95	157.39	158.85	160.32	161.80
62	163.29	164.79	166.31	167.83	169.37
63	170.92	172.49	174.06	175.65	177.25
64	178.86	180.48	182.12	183.77	185.43
65	187.10	188.79	190.49	192.20	193.93
66	195.67	197.42	199.18	200.96	202.75
67	204.56	206.38	208.21	210.06	211.92
68	213.79	215.68	217.58	219.50	221.43
69	223.37	225.33	227.30	229.29	231.29

VAPOR TENSION OF WATER (Continued)

Tension of Aqueous Vapor, 0 to 100° C.

In millimeters of mercury.

Temp. ° C.	0.0	0.2	0.4	0.6	0.8
70	233.31	235.34	237.39	239.45	241.52
71	243.62	245.72	247.85	249.98	252.14
72	254.30	256.49	258.69	260.91	263.14
73	265.38	267.65	269.93	272.23	274.54
74	276.87	279.21	281.58	283.96	286.35
75	288.76	291.19	293.64	296.11	298.59
76	301.09	303.60	306.14	308.69	311.26
77	313.85	316.45	319.07	321.72	324.38
78	327.05	329.75	332.47	335.20	337.95
79	340.73	343.52	346.33	349.16	352.01
80	354.87	357.76	360.67	363.59	366.54
81	369.51	372.49	375.50	378.53	381.58
82	384.64	387.73	390.84	393.97	397.12
83	400.29	403.49	406.70	409.94	413.19
84	416.47	419.77	423.09	426.44	429.81
85	433.19	436.60	440.04	443.49	446.97
86	450.47	454.00	457.54	461.11	464.71
87	468.32	471.96	475.63	479.32	483.03
88	486.76	490.52	494.31	498.12	501.95
89	505.81	509.69	513.60	517.53	521.48
90	525.47	529.48	533.51	537.57	541.65
91	545.77	549.90	554.07	558.26	562.47
92	566.71	570.98	575.28	579.61	583.96
93	588.33	592.74	597.17	601.64	606.13
94	610.64	615.19	619.76	624.37	629.00
95	633.66	638.35	643.06	647.81	652.59
96	657.40	662.23	667.10	672.00	676.92
97	681.88	686.87	691.89	696.93	702.02
98	707.13	712.27	717.44	722.65	727.89
99	733.16	738.46	643.80	749.17	754.57
100	760.00	765.47	770.97	776.50	782.07

VAPOR TENSION OF WATER

Tension of Aqueous Vapor, 100–230° C.

Giving the vapor tension in millimeters of mercury, in pounds per square inch and the corresponding temperature Fahrenheit.

(From Regnault—Smithsonian Tables.)

Temp.* ° C.	Pressure. mm.	Pressure. Pounds per sq.in.	Temp.* ° F.	Temp.* ° C.	Pressure. mm.	Pressure. Pounds per sq.in.	Temp.* ° F.
100	760.00	14.70	212.0	145	3125.55	60.44	293.0
101	787.59	15.23	213.8	146	3212.74	62.13	294.8
102	816.01	15.79	215.6	147	3301.87	63.86	296.6
103	845.28	16.35	217.4	148	3392.98	65.62	298.4
104	875.41	16.94	219.2	149	3486.09	67.41	300.2
105	906.41	17.53	221.0	150	3581.2	69.26	302.0
106	938.31	18.15	222.8	151	3678.4	71.14	303.8
107	971.14	18.78	224.6	152	3777.7	73.06	305.6
108	1004.91	19.44	226.4	153	3879.2	75.02	307.4
109	1039.65	20.11	228.2	154	3982.8	77.03	309.2
110	1075.37	20.80	230.0	155	4088.6	79.07	311.0
111	1112.09	21.51	231.8	156	4196.6	81.22	312.8
112	1149.83	22.24	233.6	157	4306.9	83.29	314.6
113	1188.61	22.99	235.4	158	4419.5	85.47	316.4
114	1228.47	23.76	237.2	159	4534.4	87.69	318.2
115	1269.41	24.55	239.0	160	4651.6	89.96	320.0
116	1311.47	25.37	240.8	161	4771.3	92.27	321.8
117	1354.66	26.20	242.6	162	4893.4	94.63	323.6
118	1399.02	27.06	244.4	163	5017.9	97.04	325.4
119	1444.55	27.94	246.2	164	5145.0	99.50	327.2
120	1491.28	28.85	248.0	165	5274.5	102.01	329.0
121	1539.25	29.78	249.8	166	5406.7	104.56	330.8
122	1588.47	30.73	251.6	167	5541.4	107.18	332.6
123	1638.96	31.70	253.4	168	5678.8	109.84	334.4
124	1690.76	32.70	255.2	169	5818.9	112.53	336.2
125	1743.88	33.72	257.0	170	5961.7	115.29	338.0
126	1798.35	34.78	258.8	171	6107.2	118.11	339.8
127	1854.20	35.86	260.6	172	6255.5	120.98	341.6
128	1911.47	36.97	262.4	173	6406.6	123.90	343.4
129	1970.15	38.11	264.2	174	6560.6	126.87	345.2
130	2030.28	39.26	266.0	175	6717.4	129.91	347.0
131	2091.94	40.47	267.8	176	6877.2	133.00	348.8
132	2155.03	41.68	269.6	177	7040.0	136.15	350.6
133	2219.69	42.93	271.4	178	7205.7	139.35	352.4
134	2285.92	44.21	273.2	179	7374.5	142.62	354.2
135	2353.73	45.52	275.0	180	7546.4	145.93	356.0
136	2423.16	46.87	276.8	181	7721.4	149.32	357.8
137	2494.23	48.24	278.6	182	7899.5	152.77	359.6
138	2567.00	49.65	280.4	183	8080.8	156.32	361.4
139	2641.44	51.06	282.2	184	8265.4	159.84	363.2
140	2717.63	52.55	284.0	185	8453.2	163.47	365.0
141	2795.57	54.07	285.8	186	8644.4	167.17	366.8
142	2875.30	55.60	287.6	187	8838.8	170.94	368.6
143	2956.86	57.16	289.4	188	9036.7	174.76	370.4
144	3040.26	58.79	291.2	189	9238.0	178.65	372.2

* These are the temperatures at which water boils under pressures shown.

VAPOR TENSION OF WATER (Continued)

Tension of Aqueous Vapor, 100–230° C.

Giving the vapor tension in millimeters of mercury, in pounds per square inch and the corresponding temperature Fahrenheit.)

(From Regnault—Smithsonian Tables.)

Temp. ° C.	Pressure. mm.	Pressure. Pounds per sq.in.	Temp. ° F.	Temp. ° C.	Pressure. mm.	Pressure. Pounds. per sq.in.	Temp. ° F.
190	9442.7	182.61	374.0	210	14324.8	277.01	410.0
191	9650.9	186.63	375.8	211	14611.3	282.58	411.8
192	9862.7	190.72	377.6	212	14902.2	288.21	413.6
193	10078.0	194.88	379.4	213	15197.5	293.92	415.4
194	10297.0	199.13	381.2	214	15497.2	299.72	417.2
195	10519.6	203.43	383.0	215	15801.3	305.57	419.0
196	10746.0	207.81	384.8	216	16109.9	311.57	420.8
197	10975.0	212.25	386.6	217	16423.2	317.62	422.6
198	11209.8	216.77	388.4	218	16740.9	323.78	424.4
199	11447.5	221.37	390.2	219	17063.3	330.01	426.2
200	11689.0	226.04	392.0	220	17390.4	336.30	428.0
201	11934.4	230.79	393.8	221	17722.1	342.70	429.8
202	12183.7	235.61	395.6	222	18058.6	349.21	431.6
203	12437.0	240.54	397.4	223	18399.9	355.81	433.4
204	12694.3	245.49	399.2	224	18746.1	362.50	435.2
205	12955.7	250.53	401.0	225	19097.0	369.29	437.0
206	13221.1	255.67	402.8	226	19452.9	376.17	438.8
207	13490.8	260.88	404.6	227	19813.8	383.15	440.6
208	13764.5	266.18	406.4	228	20179.6	390.22	442.4
209	14042.5	271.55	408.2	229	20550.5	397.40	444.2

VAPOR TENSION OF MERCURY

(From Gebhardt, Hertz, Regnault, Van der Plaats, and others.)

Temp. ° C.	Pressure, mm.	Temp. ° C.	Pressure, mm.
0	0.0004	200	18.3
20	0.0013	220	33.7
40	0.006	240	59.
60	0.03	260	98
80	0.09	280	156.
100	0.28	300	246.
120	0.8	320	371.
140	1.85	340	548.
160	4.4	360	790.
180	9.2		

LOWERING OF VAPOR PRESSURE BY SALTS IN AQUEOUS SOLUTIONS

The table gives the reduction of the vapor pressure in millimeters due to the presence of the number of grammolecules of salt per liter of water given at the head of the columns, at the temperature 100° C., at which temperature the vapor pressure of pure water is 76.0 centimeters.

(From Smithsonian Tables.)

Substance	0.5	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0
Ammonium chloride.	12.0	23.7	45.1	69.3	94.2	118.5	138.2	179.0	213.8
Barium chloride.	16.4	36.7	77.6						
Calcium chloride.	17.0	39.8	95.3	166.6	241.5	319.5			
Ferrous sulphate. . . .	5.8	10.7	24.0	42.4					
Potassium hydroxide.	15.0	29.5	64.0	99.2	140.0	181.8	223.0	309.5	387.8
Potassium iodide. . . .	12.5	25.3	52.2	82.6	112.2	141.5	171.8	225.5	278.5
Sodium chloride.	12.3	25.2	52.1	80.0	111.0	143.0	176.5		
Sodium hydroxide. . .	11.8	22.8	48.2	77.3	107.5	139.1	172.5	243.3	314.0
Sulphuric acid.	12.9	26.5	62.8	104.0	148.0	198.4	247.0	343.2	
Zinz sulphate.	4.9	10.4	21.5	42.1	66.2				

CONSTANTS OF THE KINETIC THEORY OF GASES

Giving the velocity, mean free path and diameter of molecules for various gases and vapors at 0° C. and 760 mm. pressure.

Gas.	Mean vel. cm./s.	Mean free path, cm.	Diam. cm.	Observer.
Ammonia.	5.8×10^4	6.2×10^{-6}	3.9×10^{-3}	Graham, 1846
Argon.	3.81	8.84	3.23	Schultze, 1901
Benzene.	2.7	21	6.6	
Carbon dioxide	3.6	5.6	4.1	Breitenbach 1899
Chlorine.	2.86	4.07	4.76	Graham, 1846
Chloroform. . .	2.2	2.3	6.3	Puluj, 1878
Ether.	2.8	2.1	6.6	Puluj, 1878
Ethyl alcohol.	3.5	3.2	5.3	Puluj, 1878
Helium.	12.02	25.1	1.9	Schultze, 1901
Hydrogen. . . .	16.94	16.3	2.38	Puluj, 1878
Nitrogen.	4.53	8.61	3.27	Markowski, 1904
Oxygen.	4.25	9.06	3.19	Markowski, 1904
Water vapor. .	5.7	5.7	4.0	Puluj, 1878

NUMBER OF MOLECULES IN A MOLECULE-GRAM

Perrin, 1909–11. . . . . 6.2×10^{23}
Perrin (Brownian movement). 6.85
Millikan, 1910. . . . . 6.2

MASS OF THE HYDROGEN ATOM

1.46×10^{-24} grams.

VAPOR PRESSURES OF

In centimeters

(Principally from

Temp. ° C.	Carbon bisulphide, CS_2.	Carbon dioxide, CO_2.	Carbon tetrachloride, CCl_4.	Chloroform, $CHCl_3$.	Ethyl Alcohol, C_2H_6O.	Ethyl Ether, $C_4H_{10}O$.	Acetic acid.	Acetone, C_3H_6O.	Ammonia, NH_3.
−30	....	.....	....	....	....	....	....	....	86.61
−25	....	1300.70	....	....	....	....	....	....	110.43
−20	4.73	1514.24	.98	....	.33	6.89	....	....	139.21
−15	6.16	1758.25	1.35	....	.51	8.93	....	....	173.65
−10	7.94	2034.02	1.85	....	.65	11.47	....	....	214.46
− 5	10.13	2344.13	2.48	....	.91	14.61	....	....	264.42
0	12.79	2690.66	3.29	5.97	1.27	18.44	0.35	....	318.33
5	16.00	3075.38	4.32	....	1.76	23.09	....	....	383.03
10	19.85	3499.86	5.60	10.05	2.42	28.68	0.64	....	457.40
15	24.41	3964.69	7.17	....	3.30	35.36	....	....	543.34
20	29.80	4471.66	9.10	16.05	4.45	43.28	1.18	17.96	638.78
25	36.11	5020.73	11.43	20.02	5.94	52.59	....	22.63	747.70
30	43.46	5611.90	14.23	24.75	7.85	63.48	2.01	28.10	870.10
35	51.97	6244.73	17.55	30.35	10.29	76.12	....	34.52	1007.02
40	61.75	6918.44	21.48	36.93	13.37	90.70	3.42	42.01	1159.53
45	72.95	7631.46	26.08	44.60	17.22	107.42	....	50.75	1328.73
50	85.71	.....	31.44	53.50	21.99	126.48	5.63	62.29	1515.83
55	100.16	.....	37.63	63.77	27.86	148.11	....	72.59	1721.98
60	116.45	.....	44.74	75.54	35.02	172.50	8.83	86.05	1948.21
65	134.75	.....	52.87	88.97	43.69	199.89	....	101.43	2196.51
70	155.21	.....	62.11	104.21	54.11	230.49	13.70	118.94	2467.55
75	177.99	.....	72.57	121.42	66.55	264.54	....	138.76	2763.00
80	203.25	.....	84.33	140.76	81.29	302.28	20.23	161.10	3084.31
85	231.17	.....	97.51	162.41	98.64	343.95	....	186.18	3433.09
90	261.91	.....	112.23	186.52	118.93	389.83	29.27	214.17	3810.92
95	296.63	.....	128.69	213.28	142.51	440.18	....	245.28	4219.57
100	332.51	.....	146.71	242.85	169.75	495.33	41.7	279.73	4660.82
105	372.72	.....	166.72	275.40	201.04	555.62	....	317.70	.....
110	416.41	.....	188.74	311.10	236.76	621.46	....	359.40	.....
115	463.74	.....	212.91	350.10	277.34	693.33	58.2	405.00	.....
120	514.88	.....	239.37	392.57	323.17	771.92	....	454.69	.....
							79.4		
125	569.97	.....	268.24	438.66	374.69	....	....	508.62	.....
130	629.16	.....	299.69	488.51	432.30	....	106.7	566.97	.....
135	692.59	.....	333.86	542.25	496.42	....	....	629.87	.....
140	760.40	.....	370.90	600.02	567.46	....	140.4	697.44	.....
145	832.69	.....	411.00	661.92	645.80	....	....	....	.....
150	909.59	.....	454.31	728.06	731.84	....	184.7	....	.....
155	....	.....	501.02	798.53	825.92	....	....	....	.....
160	....	.....	551.31	873.42	....	....	....	....	.....
165	....	.....	605.38	952.78	....	....	....	....	.....

VARIOUS SUBSTANCES

of mercury.

Regnault.)

Temp. ° C.	Benzol, C_6H_6.	Camphor.	Methyl alcohol, CH_4O.	Naphthalene.	Nitrous oxide, N_2O.	Pictet's fluid, $64SO_2+44CO_2$ by weight.	Sulphur dioxide, SO_2.	Hydrogen sulphide, H_2S.	Turpentine, $C_{10}H_6$.
−30	....	....	....	....	.....	58.52	28.75		
−25	....	....	.41	....	1569.49	67.64	37.38	374.93	
−20	.58	....	.63	....	1758.66	74.48	47.95	443.85	
−15	.88	....	.93	....	1968.43	89.68	60.79	519.65	
−10	1.29	....	1.35	....	2200.80	101.84	76.25	608.46	
− 5	1.83	....	1.92	....	2457.92	121.60	94.69	706.60	
0	2.53	0.006	2.68	0.002	2742.10	139.08	116.51	820.63	.21
5	3.42	....	3.69	....	3055.86	167.20	142.11	949.08	
10	4.52	0.010	5.01	0.005	3401.91	193.80	171.95	1089.63	.29
15	5.89	....	6.71	0.005	3783.17	226.48	206.49	1244.79	
20	7.56	0.015	8.87	0.008	4202.79	258.40	246.20	1415.15	.44
25	9.59	....	11.60	....	4664.14	297.92	291.60	1601.24	
30	12.02	0.026	15.00	0.013	5170.85	338.20	343.18	1803.53	.69
35	14.93	....	19.20	....	6335.98	383.80	401.48	2002.43	
40	18.36	0.060	24.35	0.032	.....	434.72	467.02	2258.25	1.08
45	22.41	....	30.61	....	.....	478.80	540.35	2495.43	
50	27.14	0.130	38.17	0.081	.....	521.36	622.00	2781.48	1.70
55	32.64	....	47.22	....	.....	....	712.50	3069.07	
60	39.01	0.255	57.99	0.183	.....	....	812.38	3374.02	2.65
65	46.34	....	70.73	....	.....	....	922.14	3696.15	
70	54.74	0.460	85.71	0.395	.....	....	....	4035.32	4.06
75	64.32	....	103.21						
80	75.19	0.915	123.85	0.74	.....	....	....	.....	6.13
85	87.46	....	147.09						
90	101.27	....	174.17	1.26	.....	....	....	.....	9.06
95	116.75	....	205.17						
100	134.01	....	240.51	1.85	.....	....	....	.....	13.11
105	153.18	....	280.63						
110	174.44	....	325.96	2.73	.....	....	....	.....	18.60
115	197.82	....	376.98						
120	223.54	....	434.18	4.02	.....	....	....	.....	25.70
125	251.71	....	498.05						
130	282.43	....	569.13	6.19	.....	....	....	.....	34.90
135	315.85	....	647.93						
140	352.07	....	733.71	....	.....	....	....	.....	46.40
145	391.21	....	830.89	....					
150	433.37	....	936.13						
155	478.65	....	....	....	.....	....	....	.....	60.50
160	527.14	....	....	....	.....	....	....	.....	68.60
165	568.30	....	....	....	.....	....	....	.....	77.50

HEAT CONDUCTIVITY

Metals

Giving the quantity of heat in calories which is transmitted per second through a plate one centimeter thick across an area of one square centimeter when the temperature difference is one degree Centigrade.

(Compiled principally from Smithsonian Tables.)

Substance.	Temp. ° C.	Conductivity	Observer.
Aluminum	18	0.48	Jaeger & Disselhorst, 1900
Antimony	0	.0442	Lorenz
Bismuth	0	.0177	Lorenz
Brass, yellow	0	.2041	Lorenz
red	0	.2460	Lorenz
Cadmium	0	.2200	Lorenz
Constantin	18	.5402	Jaeger & Disselhorst
Copper, pure	13	1.00	Angström, 1863
Copper	0	.7189	Lorenz
German silver	0	.0700	Lorenz
Gold	10–97	.75	Gray, 1895
Iron	0	.1665	Lorenz
wrought	0	.2070	J. Forbes
Lead	0	.0836	Lorenz
Mercury	0	.0148	H. F. Weber
Magnesium	0–100	.3760	Lorenz
Manganin 84Cu+4Ni+12Mn	18	.5186	Jaeger & Disselhorst
Nickel	18	.1420	Jaeger & Disselhorst
Platinum	18	.1664	Jaeger & Disselhorst
Silver	0	1.0960	H. F. Weber
Steel, hard	....	.0620	Kohlrausch
soft	....	.1110	Kohlrausch
Tin	0	.1528	Lorenz
Zinc	18	.2653	Jaeger & Disselhorst

Various Solids

Approximate Values.

Substance.	Conductivity.	Observer.
Asbestos paper	.00043	Lees-Chorlton
Brick, red	.00150	Herschel-Lebour & Dunn
Blotting paper	.00015	Lees-Chorlton
Portland cement	.00071	Lees-Chorlton
Cork	.000717	G. Forbes
Cotton wool	.000043	G. Forbes
Cotton pressed	.000033	G. Forbes
Eiderdown	.000011	Péclet, 1878
Felt	.000087	G. Forbes
Fire brick	.00028	Hutton-Blard

HEAT CONDUCTIVITY (Continued)

Various Solids (Continued)

Approximate Values.

Substance.	Conductivity.	Observer.
Glass, from	.0011	Various
Haircloth	.000042	G. Forbes
Ice	.00396	Mean
Lime	.00029	Hutton-Blard
Magnesia { from	.00016	Hutton-Blard
Magnesia { to	.00045	Hutton-Blard
Paraffin	.00023	R. Weber
Pasteboard	.00045	G. Forbes
Plaster of Paris	.00070	Lees-Chorlton
Quartz	.00036	Hutton-Blard
Sand, white dry	.00093	Herschel, Lebour & Dunn
Sandstone and hard grit, dry	.00555	Herschel, Lebour & Dunn
Sawdust	.00012	G. Forbes
Silk	.000095	Lees-Chorlton
Slate, across cleavage	.00388	Lees-Chorlton
Snow, compact layers	.00051	Hjeltström
Soil, dry	.00033	Lees-Chorlton
Vulcanite	.00087	Stefan
Vulcanized rubber, soft, { from	.00034	Herschel, Lebour & Dunn
Vulcanized rubber, soft, { to	.00054	Herschel, Lebour & Dunn
Wax (bees)	.00009	G. Forbes
Wood, fir: ‖ to axis	.00030	G. Forbes
Wood, fir: ⊥ to axis	.00009	G. Forbes

Liquids and Gases

Liquid or gas.	Temp. ° C.	Conductivity.	Observer.
Acetic acid	9–15	.000472	H. F. Weber
Air	0	.0000568	Winkelmann
Alcohol, ethyl	9–15	.000423	H. F. Weber
Carbon dioxide	0	.0000307	Winkelmann
Carbon disulphide	9–15	.000343	H. F. Weber
Chloroform	9–15	.000288	H. F. Weber
Ether	9–15	.000303	H. F. Weber
Glycerine	9–15	.000637	Graetz
Hydrogen	0	.000327	Winkelmann
Nitrogen	7–8	.0000524	Winkelmann
Oil, olive	....	.000395	Wachsmuth
Oxygen	7–8	.0000563	Winkelmann
Water	0	.00120	H. F. Weber

HIGH AND LOW TEMPERATURES OBTAINED BY VARIOUS MEANS

Absolute zero, −273° C.

Freezing-point of helium	−272° C
Freezing-point of hydrogen	−257
Boiling-point of hydrogen	−253
Boiling-point of liquid air at atmospheric pressure	−192
Freezing-point of carbon dioxide	− 57
Industrial furnaces	+1700 to [illegible]800°
Bunsen burner	[illegible]70
Oxy-coal gas flame	2000
Oxy-hydrogen flame	2800
Oxy-acetylene flame	3500
Electric arc (furnace)	3500

(Sun's Temperature, 5000° C.)

HEAT VALUES OF FUEL

(From Smithsonian Tables.)

Fuel.	Calories per gm.	B.T.U. per lb.
Coal:		
Lignite		
low grade	3526	3647
high grade	3994	7189
Sub-bituminous		
low grade	5115	9207
high grade	5865	10557
Bituminous		
low grade	6088	10958
high grade	7852	14134
Semi-bituminous		
Low grade	7845	14121
high grade	8166	14699
Semi-anthracite	7612	13702
Anthracite		
low grade	6987	12577
high grade	7417	13351
Peats (air dried):		
From Franklin Co., N. Y.	5726	10307
From Sawyer Co., Wis	4867	8761
Liquid fuel:		
Petroleum ether	12215	21987
Gasoline	11250	20250
Kerosene	11100	19980
Fuel oils, heavy petroelum or refinery residue	10350	18630
Alcohol, fuel or denatured with 7–9 per cent water and denaturing material	6455	11619

HYGROMETRIC AND BAROMETRIC TABLES

CONVERSION TABLE FOR BAROMETRIC READINGS

U. S. inches to cm.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
27.0	68.580	.606	.631	.656	.682	.707	.733	.758	.783	.809
27.1	.834	.860	.885	.910	.936	.961	.987	*.012	*.037	*.063
27.2	69.088	.114	.139	.164	.190	.215	.241	.266	.291	.317
27.3	.342	.368	.393	.418	.444	.469	.495	.520	.545	.571
27.4	.596	.622	.647	.672	.698	.723	.749	.774	.799	.825
27.5	.850	.876	.901	.926	.952	.977	*.002	*.028	*.053	*.079
27.6	70.104	.130	.155	.180	.206	.231	.257	.282	.307	.333
27.7	.358	.384	.409	.434	.460	.485	.511	.536	.561	.587
27.8	.612	.638	.663	.688	.714	.739	.765	.790	.815	.841
27.9	.866	.892	.917	.942	.968	.993	*.018	*.044	*.069	*.095
28.0	71.120	.146	.171	.196	.222	.247	.273	.298	.323	.349
28.1	.374	.400	.425	.450	.476	.501	.527	.552	.577	.603
28.2	.628	.654	.679	.704	.730	.755	.781	.806	.831	.857
28.3	.882	.908	.933	.958	.984	*.009	*.035	*.060	*.085	*.111
28.4	72.136	.162	.187	.212	.238	.263	.289	.314	.339	.365
28.5	.390	.416	.441	.466	.492	.517	.543	.568	.593	.619
28.6	.644	.670	.695	.720	.746	.771	.797	.822	.847	.873
28.7	.898	.924	.949	.974	*.000	*.025	*.051	*.076	*.101	*.127
28.8	73.152	.178	.203	.228	.254	.279	.305	.330	.355	.381
28.9	.406	.432	.457	.482	.508	.533	.559	.584	.609	.635
29.0	.660	.686	.711	.736	.762	.787	.813	.838	.863	.889
29.1	.914	.940	.965	.990	*.016	*.041	*.067	*.092	*.117	*.143
29.2	74.168	.194	.219	.244	.270	.295	.321	.346	.371	.397
29.3	.422	.448	.473	.498	.524	.549	.575	.600	.625	.651
29.4	.676	.702	.727	.752	.778	.803	.829	.854	.879	.905
29.5	.930	.956	.981	*.006	*.032	*.057	*.083	*.108	*.133	*.159
29.6	75.184	.210	.235	.260	.286	.311	.337	.362	.387	.413
29.7	.438	.464	.489	.514	.540	.565	.591	.616	.341	.667
29.8	.692	.718	.743	.768	.794	.819	.845	.870	.895	.921
29.9	.946	.972	.997	*.022	*.048	*.073	*.099	*.124	*.149	*.175
30.0	76.200	.226	.251	.277	.302	.327	.353	.378	.404	.429
30.1	.454	.480	.505	.531	.556	.581	.607	.632	.658	.683
30.2	.708	.734	.759	.785	.810	.835	.861	.886	.912	.937
30.3	.962	.988	*.013	*.039	*.064	*.089	*.115	*.140	*.166	*.191
30.4	77.216	.242	.267	.293	.318	.343	.369	.394	.420	.445
30.5	.470	.496	.521	.547	.572	.597	.623	.648	.674	.699
30.6	.724	.750	.775	.801	.826	.851	.877	.902	.928	.953
30.7	.978	*.004	*.029	*.055	*.080	*.105	*.131	*.156	*.182	*.207
30.8	78.232	.258	.283	.309	.334	.359	.385	.410	.436	.461
30.9	.486	.512	.537	.563	.588	.613	.639	.664	.690	.715

TEMPERATURE CORRECTION, BRASS SCALE

METRIC

To reduce readings of a mercurial barometer with a brass scale to 0° C. subtract the appropriate quantity as found in the table.

Temp. ° C.	Observed height in centimeters.								
	70 cm.	71 cm.	72 cm.	73 cm.	74 cm.	75 cm.	76 cm.	77 cm.	78 cm.
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	.011	.011	.012	.012	.012	.012	.012	.012	.013
2	.023	.023	.023	.024	.024	.024	.024	.025	.025
3	.034	.034	.035	.035	.036	.036	.037	.037	.038
4	.045	.046	.046	.047	.048	.048	.049	.050	.050
5	0.056	0.057	0.058	0.059	0.060	0.060	0.061	0.062	0.063
6	.068	.069	.069	.071	.072	.072	.073	.074	.075
7	.079	.080	.081	.082	.083	.085	.086	.087	.088
8	.090	.092	.093	.094	.095	.097	.098	.099	.101
9	.102	.103	.104	.106	.107	.109	.110	.112	.113
10	0.113	0.114	0.116	0.118	0.119	0.121	0.122	0.124	0.126
11	.124	.126	.128	.129	.131	.133	.135	.137	.138
12	.135	.137	.139	.141	.143	.145	.147	.149	.151
13	.147	.149	.151	.153	.155	.157	.159	.161	.164
14	.158	.160	.163	.165	.167	.169	.172	.174	.176
15	0.169	0.172	0.174	0.177	0.179	0.181	0.184	0.186	0.189
16	.181	.183	.186	.188	.191	.194	.196	.199	.201
17	.192	.195	.197	.200	.203	.206	.208	.211	.214
18	.203	.206	.209	.212	.215	.218	.221	.224	.227
19	.215	.218	.221	.224	.227	.230	.233	.236	.239
20	0.226	0.229	0.232	0.236	0.239	0.242	0.245	0.248	0.252
21	.237	.241	.244	.247	.251	.254	.258	.261	.264
22	.249	.252	.256	.259	.263	.266	.270	.273	.277
23	.260	.264	.267	.271	.275	.278	.282	.286	.290
24	.271	.275	.279	.283	.287	.291	.294	.298	.302
25	0.283	0.287	0.291	0.295	0.299	0.303	0.307	0.311	0.315
26	.294	.298	.302	.306	.311	.315	.319	.323	.327
27	.305	.310	.314	.318	.323	.327	.331	.336	.340
28	.317	.321	.326	.330	.335	.339	.344	.348	.353
29	.328	.333	.337	.342	.347	.351	.356	.361	.365
30	0.339	0.344	0.349	0.354	0.359	0.363	0.368	0.373	0.378

CONVERSION TABLE FOR PRESSURE UNITS

Correct for mercury at 0° C.

Cms. of Hg.	Grams per sq.cm.	Dynes per sq.cm. (g = 980).	Lbs. per sq.in.
1	13.5956	13,323.7	0.193376
2	27.1912	26,647.4	0.386752
3	40.7868	39,971.1	0.580123
4	54.3824	53,294.8	0.773504
5	67.9780	66,618.4	0.966880
6	81.5736	79,942.1	1.160256
7	95.1692	93,265.8	1.353632
8	108.7648	106,589.5	1.547008
9	122.3604	119,913.2	1.740384

TEMPERATURE CORRECTION, GLASS SCALE

METRIC

To reduce readings of a mercurial barometer with a glass scale to 0° C. subtract the appropriate quantity as found in table.

Temp. ° C.	Observed height in centimeters.								
	70 cm.	71 cm.	72 cm.	73 cm.	74 cm.	75 cm.	76 cm.	77 cm.	78 cm.
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	.012	.012	.013	.013	.013	.013	.013	.013	.014
2	.025	.025	.025	.026	.026	.026	.026	.027	.027
3	.036	.036	.037	.037	.038	.038	.039	.039	.040
4	.048	.049	.049	.050	.051	.051	.052	.053	.053
5	0.060	0.061	0.062	0.063	0.064	0.064	0.065	0.066	0.067
6	.073	.074	.074	.076	.077	.077	.078	.079	.080
7	.085	.086	.087	.088	.089	.091	.092	.093	.094
8	.096	.098	.099	.100	.101	.103	.104	.105	.107
9	.109	.110	.111	.113	.114	.116	.117	.119	.120
10	0.121	0.122	0.124	0.126	0.127	0.129	0.130	0.132	0.134
11	.133	.135	.137	.138	.140	.142	.144	.146	.147
12	.144	.146	.148	.150	.152	.154	.156	.158	.160
13	.157	.159	.161	.163	.165	.167	.169	.171	.174
14	.169	.171	.174	.176	.178	.180	.183	.185	.187
15	0.181	0.184	0.186	0.189	0.191	0.193	0.196	0.198	0.201
16	.194	.196	.199	.201	.204	.207	.209	.212	.214
17	.205	.208	.210	.213	.216	.219	.221	.224	.227
18	.217	.220	.223	.226	.229	.232	.235	.238	.241
19	.230	.233	.236	.239	.242	.245	.248	.251	.254
20	0.242	0.245	0.248	0.252	0.255	0.258	0.261	0.264	0.268
21	.254	.258	.261	.264	.268	.271	.275	.278	.281
22	.266	.269	.273	.276	.280	.283	.287	.290	.294
23	.278	.282	.285	.289	.293	.296	.300	.304	.308
24	.290	.294	.298	.302	.306	.310	.313	.317	.321
25	0.303	0.307	0.311	0.315	0.319	0.323	0.327	0.331	0.335
26	.315	.319	.323	.327	.332	.336	.340	.344	.348
27	.326	.331	.335	.339	.344	.348	.352	.357	.361
28	.339	.343	.348	.352	.357	.361	.366	.370	.375
29	.351	.356	.360	.365	.370	.374	.379	.384	.388
30	0.363	0.368	0.373	0.378	0.383	0.387	0.392	0.397	0.402

MASS OF WATER VAPOR IN SATURATED AIR

Mass in grams per cubic meter.

(From Smithsonian Tables.)

Temp. ° C.	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
−20	0.892	0.810	0.737	0.673	0.613	0.557	0.505	0.457	0.413	0.373
−10	2.154	1.978	1.811	1.658	1.519	1.395	1.282	1.177	1.079	0.982
− 0	4.835	4.468	4.130	3.813	3.518	3.244	2.988	2.752	2.537	2.340
+ 0	4.835	5.176	5.538	5.922	6.330	6.761	7.219	7.703	8.215	8.757
10	9.330	9.935	10.574	11.249	11.961	12.712	13.505	14.339	15.218	16.144
20	17.118	18.143	19.222	20.355	21.546	22.796	24.109	25.487	26.933	28.450
30	30.039	31.704	33.449	35.275	37.187	39.187	41.279	43.465	45.751	48.138

REDUCTION OF BAROMETER READINGS TO STANDARD TEMPERATURE

Brass Scale, British Units.

The table gives the corrections for the barometer reading in inches and the temperature in degrees Fahrenheit for a brass scale graduated to be correct at 62° F. The correction is to be subtracted.

Temp. ° F.	Observed height in inches.								
	27.0	27.5	28.0	28.5	29.0	29.5	30.0	30.5	31.0
32	0.009	0.009	0.009	0.009	0.009	0.009	0.010	0.010	0.010
34	.013	.014	.014	.014	.014	.015	.015	.015	.015
36	.018	.019	.019	.019	.020	.020	.020	.021	.021
38	.023	.024	.024	.025	.025	.025	.026	.026	.027
40	.028	.029	.029	.030	.030	.031	.031	.032	.032
42	.033	.034	.034	.035	.036	.036	.038	.037	.038
44	.038	.039	.039	.040	.041	.041	.042	.043	.044
46	.043	.044	.044	.045	.046	.047	.048	.048	.049
48	.048	.049	.050	.050	.051	.052	.053	.054	.055
50	.053	.054	.055	.055	.057	.058	.058	.059	.060
52	.058	.059	.060	.060	.062	.063	.064	.065	.066
54	.062	.063	.065	.066	.067	.068	.069	.071	.072
56	.067	.068	.070	.071	.072	.074	.075	.076	.077
58	.072	.073	.075	.076	.078	.079	.080	.082	.083
60	.077	.078	.080	.081	.083	.084	.086	.087	.089
62	.082	.083	.085	.086	.088	.090	.091	.093	.094
64	.087	.088	.090	.092	.093	.095	.097	.098	.100
66	.092	.093	.095	.097	.099	.100	.102	.104	.105
68	.097	.098	.100	.102	.104	.106	.107	.109	.111
70	.102	.103	.105	.107	.109	.111	.113	.115	.117
72	.107	.108	.110	.112	.114	.116	.118	.120	.122
74	.111	.113	.116	.117	.120	.122	.124	.126	.128
76	.116	.118	.121	.123	.125	.127	.129	.131	.133
78	.121	.123	.126	.128	.130	.132	.135	.137	.139
80	.126	.128	.131	.133	.135	.138	.140	.142	.145
82	.131	.133	.136	.138	.141	.143	.146	.148	.150
84	.136	.138	.141	.143	.146	.148	.151	.153	.156
86	.141	.143	.146	.148	.151	.154	.156	.159	.162
88	.146	.148	.151	.154	.156	.159	.162	.165	.167
90	.151	.153	.156	.159	.162	.165	.167	.170	.173
92	.156	.158	.161	.164	.167	.170	.173	.176	.178
94	.160	.163	.166	.170	.172	.175	.178	.181	.184
96	.165	.168	.171	.174	.178	.181	.184	.187	.190
98	.170	.173	.177	.179	.183	.186	.189	.192	.195

CORRECTION FOR CAPILLARY DEPRESSION OF MERCURY IN A GLASS TUBE

Correction to be added.

Diam. of tube.	Height of meniscus in centimeters.							
	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18
cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
0.4	0.083	0.122	0.154	0.198	0.237			
0.5	.047	.065	.086	.119	.145	0.180		
0.6	.027	.041	.056	.078	.098	.121	0.143	
0.7	.018	.028	.040	.053	.067	.082	.097	.113
0.8	....	.020	.029	.038	.046	.056	.065	0.077
0.9	....	0.015	0.021	0.028	0.033	0.040	0.046	0.052
1.0	....	.....	.015	.020	.025	.029	.033	.037
1.1	....	.....	.010	.014	.018	.021	.024	.027
1.2	....	.....	.007	.010	.013	.015	.018	.019
1.3	....	.....	.004	.007	.010	.012	.013	.014

REDUCTION OF BAROMETER TO SEA LEVEL

Metric Units

Correction to be added (in cm.)

(From Smithsonian Tables.)

Height above sea level in meters.	Observed Height in Centimeters.					
	55	60	65	70	75	80
100	......	....	....	.0014	.0015	.0016
200	......	....	....	.0028	.0030	.0032
300	......	....	....	.0041	.0044	.0047
400	......	....	....	.0055	.0059	.0063
500	......	....	.0064	.0068	.0073	.0078
600	......	....	.0077	.0082	.0088	
700	......	....	.0090	.0096	.0102	
800	......	....	.0103	.0109	.0117	
900	......	....	.0115	.0123	.0131	
1000	.0108	.0118	.0128	.0137	.0146	
1100	.0118	.0130	.0141	.0150		
1200	.0129	.0142	.0154	.0164		
1300	.0140	.0153	.0166	.0178		
1400	.0151	.0165	.0179	.0191		
1500	.0162	.0176	.0191	.0205		
1600	.0172	.0188	.0204			
1700	.0183	.0200	.0217			
1800	.0194	.0212	.0230			
1900	.0204	.0224	.0242			
2000	.0215	.0235	.0255			
2100	.0226	.0247				
2200	.0237	.0259				
2300	.0248	.0271				
2400	.0259	.0283				
2500	.0270	.0295				

English Units

Height above sea level in feet.	Observed Height in Inches.						
	20	22	24	26	28	30	32
500	......	.....	.....	.078	.084	.090	.096
1000	......	.....	.....	.155	.167	.179	.192
1500	......	.....	.215	.233	.251	.269	
2000	......	.....	.287	.311	.335	.359	
2500	......	.....	.359	.389	.419		
3000	......	.395	.431	.467	.503		
3500	......	.461	.503	.545			
4000	......	.526	.574	.623			
4500	......	.592	.646	.701			
5000	.598	.658	.718	.779			
5500	.658	.724	.790				
6000	.718	.789	.862				
6500	.777	.655	.934				
7000	.837	.721	1.005				
7500	.897	.787	1.077				
8000	.957	.853					
8500	1.016	.918					
9000	1.076	.984					
9500	1.136	1.050					

REDUCTION OF BAROMETER TO LATITUDE 45°

Metric Scale

For latitudes below 45°, subtract the correction; for latitudes greater than 45° it is to be added. Corrections in cm.

(From Smithsonian Meteorological Tables.)

Latitude.		Observed Height of Barometer in Centimeters.					
		68	70	72	74	76	78
25°	65°	0.116	0.120	0.123	0.127	0.130	0.133
26	64	.111	.115	.118	.121	.125	.128
27	63	.106	.110	.113	.116	.119	.122
28	62	.101	.104	.107	.110	.113	.116
29	61	.096	.099	.102	.104	.107	.110
30	60	0.091	0.094	0.096	0.098	0.101	0.104
31	59	.085	.087	.090	.092	.095	.097
32	58	.079	.082	.084	.086	.089	.091
33	57	.074	.076	.078	.080	.082	.084
34	56	.068	.070	.072	.074	.076	.078
35	55	0.062	0.064	0.066	0.067	0.069	0.071
36	54	.056	.058	.059	.061	.063	.064
37	53	.050	.051	.053	.054	.056	.057
38	52	.044	.045	.046	.048	.049	.050
39	51	.038	.039	.040	.041	.042	.043
40	50	0.031	0.032	0.033	0.034	0.035	0.036
41	49	.025	.026	.027	.027	.028	.029
42	48	.019	.019	.020	.021	.021	.022
43	47	.013	.013	.013	.014	.014	.014
44	46	.006	.007	.007	.007	.007	.007

English Scale

Corrections in inches.

Latitude.		Observed Height in Inches.					
		25	26	27	28	29	30
25°	65°	0.043	0.044	0.046	0.048	0.050	0.051
26	64	.041	.043	.044	.046	.048	.049
27	63	.039	.041	.042	.044	.045	.047
28	62	.037	.039	.040	.042	.043	.045
29	61	.035	.037	.038	.039	.041	.042
30	60	0.033	0.035	0.036	0.037	0.039	0.040
31	59	.031	.032	.034	.035	.036	.037
32	58	.029	.030	.032	.033	.034	.035
33	57	.027	.028	.029	.030	.031	.032
34	56	.025	.026	.027	.028	.029	.030
35	55	0.023	0.024	0.025	0.025	0.026	0.027
36	54	.021	.021	.022	.023	.024	.025
37	53	.018	.019	.020	.021	.021	.022
38	52	.016	.017	.017	.018	.019	.019
39	51	.014	.014	.015	.015	.016	.017
40	50	0.012	0.012	0.012	0.013	0.013	0.014
41	49	.009	.010	.010	.010	.011	.011
42	48	.007	.007	.008	.008	.008	.008
43	47	.005	.005	.005	.005	.005	.006
44	46	.002	.002	.003	.003	.003	.003

RELATIVE HUMIDITY—DEW-POINT

The table gives the relative humidity of the air for temperature *t* and dew-point *d*.

(From Smithsonian Meteorological Tables.)

Depression of dew-point $t-d$ ° C.	Dew-point (*d*).				
	−10	0	+10	+20	+30
0.0	100	100	100	100	100
0.2	98	99	99	99	99
0.4	97	97	97	98	98
0.6	95	96	96	96	97
0.8	94	94	95	95	96
1.0	92	93	94	94	94
1.2	91	92	92	93	93
1.4	90	90	91	92	92
1.6	88	89	90	91	91
1.8	87	88	89	90	90
2.0	86	87	88	88	89
2.2	84	85	86	87	88
2.4	83	84	85	86	87
2.6	82	83	84	85	86
2.8	80	82	83	84	85
3.0	79	81	82	83	84
3.2	78	80	81	82	83
3.4	77	79	80	81	82
3.6	76	77	79	80	82
3.8	75	76	78	79	81
4.0	73	75	77	78	80
4.2	72	74	76	77	79
4.4	71	73	75	77	78
4.6	70	72	74	76	77
4.8	69	71	73	75	76
5.0	68	70	72	74	75
5.2	67	69	71	73	75
5.4	66	68	70	72	74
5.6	65	67	69	71	73
5.8	64	66	69	70	72
6.0	63	66	68	70	71
6.2	62	65	67	69	71
6.4	61	64	66	68	70
6.6	60	63	65	67	69
6.8	60	62	64	66	68
7.0	59	61	63	66	68
7.2	58	60	63	65	67
7.4	57	60	62	64	66
7.6	56	59	61	63	65
7.8	55	58	60	63	65

RELATIVE HUMIDITY—DEW-POINT (Continued)

Depression of dew-point $t-d$ ° C.	Dew-point (d).				
	−10	0	+10	+20	+30
8.0	54	57	60	62	64
8.2	54	56	59	61	63
8.4	53	56	58	60	63
8.6	52	55	57	60	62
8.8	51	54	57	59	61
9.0	51	53	56	58	61
9.2	50	53	55	58	60
9.4	49	52	55	57	59
9.6	48	51	54	56	59
9.8	48	51	53	56	58
10.0	47	50	53	55	57
10.5	45	48	51	54	
11.0	44	47	49	52	
11.5	42	45	48	51	
12.0	41	44	47	49	
12.5	39	42	45	48	
13.0	38	41	44	46	
13.5	37	40	43	45	
14.0	35	38	41	44	
14.5	34	37	40	43	
15.0	33	36	39	42	
15.5	32	35	38	40	
16.0	31	34	37	39	
16.5	30	33	36	38	
17.0	29	32	35	37	
17.5	28	31	34	36	
18.0	27	30	33	35	
18.5	26	29	32	34	
19.0	25	28	31	33	
19.5	24	27	30	33	
20.0	24	26	29	32	
21.0	22	25	27		
22.0	21	23	26		
23.0	19	22	24		
24.0	18	21	23		
25.0	17	19	22		
26.0	16	18	21		
27.0	15	17	20		
28.0	14	16	19		
29.0	13	15	18		
30.0	12	14	17		

REDUCTION OF PSYCHROMETRIC OBSERVATION

For the reduction of observations with the wet and dry bulb thermometer. Assuming the relative velocity of the air to the thermometer bulbs is at least three meters per second; if t is the temperature of the air as indicated by the dry bulb, t_w, the temperature of the wet bulb, B, the barometric pressure, and E_w, the vapor tension of water corresponding to t_w, then the actual vapor tension is

$$E = E_w - 0.00066B(t - t_w)[1 + 0.00115(t - t_w)].$$

The value of the term

$$0.00066B(t - t_w)[1 + 0.00115(t - t_w)]$$

is given in the following table.

(From Miller's Laboratory Physics, Ginn & Co., publishers, by permission.)

$t - t_w$	Barometric Pressure B in Centimeters.							
	70.0	71.0	72.0	73.0	74.0	75.0	76.0	77.0
°	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
1	0.047	0.048	0.048	0.049	0.050	0.050	0.051	0.052
2	.093	.094	.096	.097	.098	.100	.101	.103
3	.139	.141	.143	.145	.147	.149	.152	.154
4	.186	.189	.191	.194	.197	.199	.202	.204
5	0.232	0.236	0.239	0.243	0.246	0.249	0.252	0.256
6	.279	.283	.287	.291	.295	.299	.303	.307
7	.326	.331	.336	.340	.345	.350	.354	.359
8	.373	.379	.384	.389	.395	.400	.405	.411
9	.421	.427	.432	.438	.444	.450	.456	.462
10	0.468	0.474	0.481	0.488	0.494	0.501	0.508	0.515
11	.515	.522	.530	.537	.544	.551	.559	.566
12	.562	.570	.578	.586	.594	.602	.611	.619
13	.610	.618	.627	.636	.645	.653	.662	.671
14	.658	.667	.676	.686	.695	.705	.714	.723
15	0.706	0.716	0.726	0.736	0.746	0.756	0.766	0.776
16	.754	.764	.775	.786	.796	.807	.818	.829
17	.802	.813	.824	.836	.847	.859	.870	.882
18	.850	.862	.874	.886	.898	.910	.922	.935
19	.898	.911	.923	.936	.949	.962	.975	.987
20	0.946	0.960	0.973	0.987	1.000	1.014	1.027	1.041

VELOCITY OF SOUND

Solids

Approximate values.
(From Smithsonian Tables.)

Substance.	Temp. °C.	Veloc., meters per sec.	Veloc., feet per sec.	Observer.
Metals:				
Aluminum	....	5104	16740	Masson
Brass	....	3500	11480	Various
Cadmium	....	2307	7570	Masson
Cobalt	....	4724	15500	Masson
Copper	20	3560	11670	Wertheim
Copper	100	3290	10800	Wertheim
Copper	200	2950	9690	Wertheim
Gold, soft	20	1743	5717	Wertheim
Gold, hard	....	2100	6890	Various
Iron and soft steel	....	5000	16410	Various
Iron	20	5130	16820	Wertheim
Iron	100	5300	17390	Wertheim
Iron	200	4720	15480	Wertheim
Iron cast steel	20	4990	16360	Wertheim
Iron cast steel	200	4790	15710	Wertheim
Lead	20	1227	4026	Wertheim
Magnesium	....	4602	15100	Melde
Nickel	....	4973	16320	Masson
Palladium	....	3150	10340	Various
Platinum	20	2690	8815	Wertheim
Platinum	100	2570	8437	Wertheim
Platinum	200	2460	8079	Wertheim
Silver	20	2610	8553	Wertheim
Silver	100	2640	8658	Wertheim
Tin	....	2500	8200	Various
Zinc	....	3700	12140	Various
Various:				
Brick	....	3652	11980	Chladni
Clay rock	....	3480	11420	Gray and Milne
Cork	....	500	1640	Stefan
Granite	....	3950	12960	Gray and Milne
Marble	....	3810	12500	Gray and Milne
Paraffin	15	1304	4280	Warburg
Slate	....	4510	14800	Gray and Milne
Tallow	16	390	1280	Warburg
Glass, from	....	5000	16410	Various
Glass, to	....	6000	19690	Various
Ivory	....	3013	9886	Ciccone & Campanile
Vulcanized rubber	0	54	177	Exner
Wax	17	880	2890	Stefan
Woods:				
Ash, along the fiber	....	4670	15310	Wertheim
Ash, across the rings	....	1390	4570	Wertheim
Ash, along the rings	....	1260	4140	Wertheim
Beech, along the fiber	....	3340	10960	Wertheim
Elm, along the fiber	....	4120	13516	Wertheim
Fir, along the fiber	....	4640	15220	Wertheim
Maple, along the fiber	....	4110	13470	Wertheim
Oak, along the fiber	....	3850	12620	Wertheim
Pine, along the fiber	....	3320	10900	Wertheim
Poplar, along the fiber	....	4280	14050	Wertheim
Sycamore, along fiber	....	4460	14640	Wertheim

VELOCITY OF SOUND (Continued)

Liquids and Gases

(From Smithsonian Tables.)

Substance.	Temp. °C.	Veloc., meters per sec.	Veloc., feet per sec.	Observer.
Liquids:				
Alcohol, 95%	12.5	1241.	4072.	Dorsing, 1908
Alcohol	20.5	1213.	3890.	Dorsing, 1908
Ammonia, conc	16.	1663.	5456.	Dorsing, 1908
Benzine	17.	1166.	3826.	Dorsing, 1908
Carbon bisulphide	15.	1161.	3809.	Dorsing, 1908
Chloroform	15.	983.	3225.	Dorsing, 1908
Ether	15.	1032.	3386.	Dorsing, 1908
NaCl, 10% sol	15.	1470.	4823.	Dorsing, 1908
NaCl, 15% sol	15.	1530.	5020.	Dorsing, 1908
NaCl, 20% sol	15.	1650.	5414.	Dorsing, 1908
Turpentine oil	15.	1326.	4351.	Dorsing, 1908
Water, air-free	13.	1441.	4728.	Dorsing, 1908
Water, air-free	19.	1461.	4794.	Dorsing, 1908
Water, air-free	31.	1505.	4938.	Dorsing, 1908
Water, Lake Geneva	9.	1435.	4708.	Colladon-Sturm
Water, Seine River	15.	1437.	4714.	Wertheim
Water, Seine River	30.	1528.	5013.	Wertheim
Water, Seine River	60.	1724.	5657.	Wertheim
Gases:				
Air, dry, CO_2-free	0.	331.78	1088.5	Rowland
Air, dry,	0.	331.36	1087.1	Violle, 1900
Air, dry, CO_2-free	0.	331.92	1089.0	Thiesen, 1908
Air 1 atmosphere	0.	331.7	1088.	Mean
Air 25 atmospheres	0.	332.0	1089.	Mean (Witkowski)
Air 50 atmospheres	0.	334.7	1098.	Mean (Witkowski)
Air 100 atmospheres	0.	350.6	1150.	Mean (Witkowski)
Air	20.	344.	1129.	
Air	100.	386.	1266.	Stevens
Air	500.	553.	1814.	Stevens
Air	1000.	700.	2297.	Stevens
Ammonia	0.	415.	1361.	Masson
Carbon monoxide	0.	337.1	1106.	Wullner
Carbon dioxide	0.	258.0	846.	Bückendahl, 1906
Carbon disulphide	0.	189.	606.	Masson
Chlorine	0.	205.3	674.	Strecker
Ethylene	0.	314.	1030.	Dulong
Hydrogen	0.	1269.5	4165.	Dulong
Illuminating gas	0.	490.4	1609.	Zoch
Methane	0.	432.	1417.	Masson
Nitric oxide	0.	325.	1066.	Masson
Nitrous oxide	0.	261.8	859.	Dulong
Oxygen	0.	317.2	1041.	Dulong
Vapors:				
Alcohol	0.	230.6	756.	Masson
Ether	0.	179.2	588.	Masson
Water	0.	401.	1315.	Masson
Water	100.	404.8	1328.	Treitz, 1903
Water	130.	424.4	1392.	Treitz, 1903

MUSICAL SCALES

(From Miller's Laboratory Physics, Ginn & Co., publishers, by permission.)

Vibration Frequency of Tones in the Musical Scale for Higher or Lower Octaves are Obtained by Multiplying by Some Power of 2

Scientific diatonic scale. $C_3 = 256$.		Musical equal-tempered chromatic scale. $A_3 = 435$.			
C_3	**256.**	C_3	258.65	G_3	387.54
D_3	288.	$C\#_3$	274.03	$G\#_3$	410.58
E_3	320.	D_3	290.33	A_3	**435.**
F_3	341.33	$D\#_3$	307.59	$A\#_3$	460.87
G_3	384.	E_3	325.88	B_3	488.27
A_3	426.66	F_3	345.26	C_4	517.30
B_3	480.	$F\#_3$	365.79		
C_4	512.				

ELECTRICITY AND MAGNETISM

SPARKING POTENTIAL OR DIELECTRIC STRENGTH

AIR

Potential in volts necessary to produce a spark in air at atmospheric pressure and ordinary temperatures, the potential required depends on the shape and size of the electrodes and increases with the pressure of the air.

(From Smithsonian Tables.)

Spark length, cm.	Point electrodes, steady potential.	Ball electrodes, 1 cm. diam. Steady potential.	Ball electrodes, 1 cm. diam. Alternating potential.
.02	....	1530	
.04	....	2430	
.06	....	3240	
.08	....	3990	3770
.10	3720	4560	4400
.2	4680	8490	7510
.3	5310	11340	10480
.4	5970	14340	13360
.5	6300	17220	16140
.6	6840	20070	18700
.8	8070	24780	23820
1.0	8670	27810	28380
2.0	10140	45480	42950
3.0	11250	46710	
4.0	12210	49100	
5.0	13050	50310	
6.0			
8.0	....	52400	
10.0	....	74300	

SPECIFIC INDUCTIVE CAPACITY

Solids

Atmospheric temperatures except where noted.

(From Smithsonian Tables.)

Substance.	Wave length.	Specific inductive capacity.	Observer.
Asphalt	∞	2.68	v. Pirani, 1903
Caoutchouc	∞	2.22	Gordon, 1879
Calcspar:			
⊥ to axis	∞	8.49	Fallinger, 1902
‖ to axis	∞	7.56	Fallinger, 1902
Diamond	∞	16.5	v. Pirani, 1903
Ebonite	∞	2.72	Winklemann, 1889
Glass flint, extra heavy	∞	9.90	Hopkinson, 1891
hard crown	∞	6.96	Hopkinson, 1891
lead (Powell)	∞	5.4–8.0	Gray-Dobbie, 1898
Jena, barium	∞	7.8–8.5	Löwe, 1898
Gutta percha	.....	3.3–4.9	(submarine-data)
Ice −5° C	1200	2.85	Thwing, 1894
−18°	5000	3.16	Abegg, 1897
−190°	75	1.76–1.88	Behn-Kiebitz, 1904
Iodine, cryst	75	4.00	Schmidt, 1903
Marble, Carrara	75	8.3	Schmidt, 1903
Mica	∞	5.66–5.97	Elsas, 1891
Mica, Canadian amber	∞	3.0	E. Wilson
Paraffin	∞	2.10	Zietkowski, 1900
Phosphorus, yellow	75	3.60	Schmidt, 1903
Porcelain, hard (Royal Berlin)	∞	5.73	Starke, 1897
Quartz:			
⊥ to axis	∞	4.69	Fallinger, 1902
‖ to axis	∞	5.06	Fallinger, 1902
Selenium	∞	6.13	Vonwiller-Mason, 1907
Shellac	∞	3.10	Winkelmann, 1889
Sulphur, amorphous	∞	3.98	v. Pirani, 1903
Sulphur, cast, fresh	∞	4.22	v. Pirani, 1903
Wood, dry:			
red beech	∞	4.83–2.51	
red beech	∞	7.73–3.63	
oak	∞	4.22–2.46	
oak	∞	6.84–3.64	

SPECIFIC INDUCTIVE CAPACITY (Continued)

Gases

The specific inductive capacity of a vacuum is taken as unity. Wave-lengths of the measuring current greater than 10,000 cm.

(Dielectric constant.)

Gas.	Temp. ° C.	Pressure in atmos-pheres.	Specific inductive capacity.	Observer.
Air	0	1	1.000590	Boltzmann, 1875
Air	19	20	1.0108	Tangl, 1907
Air	....	40	1.0218	Tangl, 1907
Air	....	60	1.0330	Tangl, 1907
Air	....	80	1.0439	Tangl, 1907
Air	....	100	1.0548	Tangl, 1907
Ammonia	20	1	1.00718	Bädeker, 1901
Carbon bisulphide	0	1	1.00290	Klemenčič
Carbon bisulphide	100	1	1.00239	Bädeker
Carbon dioxide	0	1	1.000985	Klemenčič
Carbon dioxide	15	10	1.008	Linde, 1895
Carbon dioxide	....	20	1.020	Linde, 1895
Carbon dioxide	....	40	1.060	Linde, 1895
Carbon monoxide	0	1	1.000690	Boltzmann
Ethylene	0	1	1.00131	Boltzmann
Hydrochloric acid	100	1	1.00258	Bädeker
Hydrogen	0	1	1.000264	Boltzmann
Methane	0	1	1.000944	Boltzmann
Nitrous oxide (N_2O)	0	1	1.00116	Boltzmann
Nitrous oxide (N_2O)	15	10	1.010	Linde, 1895
Nitrous oxide (N_2O)	....	20	1.025	Linde, 1895
Nitrous oxide (N_2O)	....	40	1.070	Linde, 1895
Sulphur dioxide	0	1	1.00993	Bädeker
Sulphur dioxide	0	1	1.00905	Klemenčič
Water vapor	145	4	1.00705	Bädeker

Liquids

Where the wave-length is not specified it is greater than 10,000 cm.

Liquid.	Temp. ° C.	Wave length.	Specific inductive capacity.	Observer.
Acetic acid	18	∞	9.7	Francke, 1893
Acetone	0	∞	26.6	Abegg, 1897
Air	−191	∞	1.43	v. Pirani, 1903
Alcohol:				
amyl	0	∞	17.4	Abegg-Seitz, 1899
amyl	+20	∞	16.0	Abegg-Seitz, 1899
ethyl	frozen	∞	2.7	Abegg-Seitz, 1899
ethyl	−120	∞	54.6	Abegg-Seitz, 1899

SPECIFIC INDUCTIVE CAPACITY (Continued)

Liquids (Continued)

Liquid.	Temp. ° C.	Wave length.	Specific inductive capacity.	Observer.
Alcohol:				
ethyl	−80	∞	44.3	Abegg-Seitz, 1899
ethyl	−40	∞	35.3	Abegg-Seitz, 1899
ethyl	0	∞	28.4	Abegg-Seitz, 1899
ethyl	+20	∞	25.8	Abegg-Seitz, 1899
ethyl	17	200	24.4	Drude, 1896
ethyl	17	75	23.0	Drude, 1896
ethyl	17	53	20.6	Marx, 1898
ethyl	17	4	8.8	Marx, 1898
ethyl	17	0.4	5.0	Lampa, 1896
methyl	0	∞	35.0	Abegg-Seitz, 1899
methyl	+20	∞	31.2	Abegg-Seitz, 1899
propyl	0	∞	24.8	Abegg-Seitz, 1899
propyl	+20	∞	22.2	Abegg-Seitz, 1899
Ammonia	−34	75	21–23	Goodwin-Thompson, 1899
Amyl acetate	19	∞	4.81	Löwe, 1898
Anilin	18	∞	7.316	Turner, 1900
Benzol (Benzene)	18	∞	2.288	Turner, 1900
Bromine	23	84	3.18	Schlundt
Carbon bisulphide	20	∞	2.626	Tangl, 1903
Carbon dioxide	−5	∞	1.60	Linde, 1895
Chlorine	−60	∞	2.15	Linde, 1895
Chloroform	18	∞	5.2	Turner, 1900
Ethyl ether	0	∞	4.68	Abegg, 1897
Ethyl ether	20	∞	4.30	Tangl, 1903
Glycerine	15	1200	56.2	Thwing, 1894
Hydrogen peroxide 46% in H_2O	18	75	84.7	Calvert, 1900
Hydrogen sulphide	10	∞	5.93	Eversheim, 1904
Nitrous oxide, N_2O	−88	∞	1.93	Hasenhörl, 1900
Oils:				
castor	11	∞	4.67	Arons-Rubens, 1892
cottonseed	14	∞	3.10	Salvioni, 1888
linseed	13	∞	3.35	Salvioni, 1888
olive	20	∞	3.11	Heinke, 1896
petroleum	....	2000	2.13	Marx
sperm	20	∞	3.17	Hopkinson, 1881
turpentine	20	∞	2.23	Hopkinson, 1881
Oxygen	−182	∞	1.49	Fleming-Dewar, 1896
Phenol	48	73	9.68	Drude, 1896
Sulphur dioxide	20	∞	14.0	Eversheim, 1904
Water	18	∞	81.07	Turner, 1900

SPARKING POTENTIAL OR DIELECTRIC STRENGTH

Various Insulators.

Potential to puncture in kilovolts per centimeter. 1 kilovolt = 1000 volts.

Substance.	Thickness used mm.	Kilovolts per cm.
Air, liquid	....	40–90
Ebonite	....	300–1100
Fiber	....	20
Glass	....	300–1500
Guttapercha	....	80–200
Kerosene	1.0	164
Linen, varnished	....	100–200
Mica	0.1	1500–2200
Mica	1.0	300–700
Oils:		
castor	0.2	190
castor	1.0	130
cottonseed	....	70
lard	0.2	140
lard	1.0	40
linseed, raw	0.2	185
raw	1.0	90
boiled	0.2	190
boiled	1.0	80
lubricating	....	50
olive	0.2	170
olive	1.0	75
paraffin	0.2	215
paraffin	1.0	160
sperm, mineral	0.2	180
mineral	1.0	85
natural	0.2	195
natural	1.0	90
turpentine	0.2	160
turpentine	1.0	110
Papers:		
beeswaxed	....	770
blotting	....	150
Manilla	....	25
paraffined	....	500
varnished	....	100–250
Paraffin:		
melted	....	75
solid, melt. point 43°	....	350
solid, melt. point 70°	....	450
Rubber	....	160–500
Vaseline	....	90–130
Xylol	0.2	140
Xylol	1.0	80

ELECTROMOTIVE FORCE AND COMPOSITION OF VOLTAIC CELLS

Standard Cells

(From Smithsonian Tables.)

Name of cell.	Negative pole.	Solution.	Positive pole.	Depolarizer.	E.M.F.
Weston normal. .	Cadmium amalgam. . .	Saturated solution of $CdSO_4$.	Mercury. .	Paste of Hg_2SO_4 and $CdSO_4$	1.0191 at 20° C.
Clark standard. .	Zinc amalgam.	Saturated solution of $ZnSO_4$.	Mercury. .	Paste of Hg_2SO_4 and $ZnSO_4$.	1.434 at 15° C.

Temperature equations:

Clark cell: $E_t = 1.434[1 - 0.00119(t-15) - 0.000007(t-15)^2]$

Weston cell: $E_t = 1.0191[1 - 0.0000406(t-20) - 0.00000095(t-20)^2]$

Double Fluid Cells

Name of cell.	Negative pole.	Solution.	Positive pole.	Solution.	E.M.F. in volts.
Bunsen.	Amal. zinc.	1 part H_2SO_4 to 12 parts H_2O. . . .	Carbon. . .	Fuming nitric acid.	1.94
Bunsen.	Amal. zinc.	1 part H_2SO_4 to 12 parts H_2O. . . .	Carbon. . .	HNO_3, density, 1.38.	1.86
Bichromate.	Amal. zinc.	12 parts $K_2Cr_2O_7$ to 25 parts H_2SO_4 and 100 parts H_2O.	Carbon. . .	1 part H_2SO_4 to 12 parts H_2O	2.00
Bichromate.	Amal. zinc.	1 part H_2SO_4 to 12 parts H_2O. . . .	Carbon. . .	12 parts $K_2Cr_2O_7$ to 100 parts H_2O.	2.03
Daniell.	Amal. zinc.	1 part H_2SO_4 to 4 parts H_2O.	Copper. . .	Saturated solution of $CuSO_4+5H_2O$.	1.06
Daniell.	Amal. zinc.	5% solution of $ZnSO_4+6H_2O$. . . .	Copper. . .	Saturated solution of $CuSO_4+5H_2O$.	1.08
Daniell	Amal. zinc.	1 part NaCl to 4 parts H_2O.	Copper. . .	Saturated solution of $CuSO_4+5H_2O$.	1.05
Grove.	Amal. zinc.	1 part H_2SO_4 to 12 parts H_2O. . . .	Platinum .	Fuming nitric acid.	1.93
Grove.	Amal. zinc.	Solution of $ZnSO_4$.	Platinum .	HNO_3 density 1.33.	1.66

ELECTROMOTIVE FORCE AND COMPOSITION OF VOLTAIC CELLS (Continued)

Double Fluid Cells (Continued)

Name of cell.	Negative pole.	Solution.	Positive pole.	Solution.	E.M.F. in volts.
Grove	Amal. zinc	H_2SO_4 solution, density 1.136	Platinum	HNO_3 density 1.33	1.79
Grove	Amal. zinc	H_2SO_4 solution, density 1.14	Platinum	HNO_3 density 1.19	1.66
Grove	Amal. zinc	NaCl solution	Platinum	HNO_3 density, 1.33	1.88

Single Fluid Cells

Name of cell.	Negative pole.	Solution.	Positive pole.	E.M.F.
Leclanché	Amal. zinc	Solution of sal-ammoniac	Carbon, depolarizer: manganese peroxide with powd. carbon	1.46
Edison-Lalande	Amal. zinc	Solution of caustic potash	Copper, depolarizer, CuO	0.70
Chloride of silver	Zinc	23% sol. of sal-ammoniac	Silver, depolarizer: silver chloride	1.02

Storage Cells

Name of cell.	Negative pole.	Solution.	Positive pole.	E.M.F.
Lead accumulator	Lead	H_2SO_4 solution of density 1.1	PbO_2	2.2
Regnier (1)	Copper	$CuSO_4+H_2SO_4$	PbO_2	1.68 to 0.85, average, 1.3
Regnier (2)	Amal. zinc	$ZnSO_4$ solution	PbO_2 in H_2SO_4	2.36
Main	Amal. zinc	H_2SO_4, density about 1.1	PbO_2	2.50
Edison	Iron	KOH, 20% solution	A nickel oxide	1.1, mean of full discharge

CONTACT DIFFERENCE OF POTENTIAL

Metals

The values in the table give the potential in volts of the metal at the top of the column with respect to the metal named at the left.

(Tabulated from results by Pellat, 1881.)

	Antimony.	Bismuth.	Brass.	Copper.	Gold.	Iron.
Antimony	0	−.08	−.06	−.30	−.48	−.15
Bismuth	+.08	0	−.07	−.22	−.40	−.07
Brass	+.06	+.07	0	+.15	−.33	0
Copper	+.30	+.22	−.15	0	−.18	+.15
Gold	+.48	+.40	+.33	+.18	0	+.33
Iron	+.15	+.07	0	−.15	−.33	0
Lead	−.26	−.34	−.41	−.56	−.74	−.41
Nickel	+.06	−.02	−.09	−.24	−.42	−.09
Platinum	+.46	+.39	+.32	+.17	−.01	+.32
Silver	+.50	+.42	+.35	+.20	+.02	+.35
Tin	−.16	−.24	−.31	−.46	−.64	−.31
Zinc	−.41	−.49	−.56	−.71	−.89	−.56
Carbon*	.....	.....	+.41	+.37	.....	+.48
Mercury	.....	.....	.....	+.31	.....	+.50

	Lead.	Nickel.	Platinum.	Silver.	Tin.	Zinc.	Carbon.
Antimony	+.26	−.06	−.46	−.50	+.16	+.41	
Bismuth	+.34	+.02	−.39	−.42	+.24	+.49	
Brass	+.41	+.09	−.32	−.35	+.31	+.56	−.41
Copper	+.56	+.24	−.17	−.20	+.46	+.71	−.37
Gold	+.74	+.42	+.01	−.02	+.64	+.89	
Iron	+.41	+.09	−.32	−.35	+.31	+.56	−.48
Lead	0	−.32	−.73	−.76	−.10	+.15	−.85
Nickel	+.32	0	−.41	−.44	+.22	+.47	
Platinum	+.73	+.41	0	−.03	+.63	+.88	−.11
Silver	+.76	+.44	+.03	0	+.66	+.91	
Tin	+.10	−.22	−.63	−.66	0	+.25	−.79
Zinc	−.15	−.47	−.88	−.91	−.25	0	−1.10
Carbon*	+.85	.....	+.11	.....	+.79	+1.10	0
Mercury	....	.....	+.16	....	....	....	+.09

* Ayrton and Perry.

DIFFERENCE OF POTENTIAL BETWEEN METALS IN SOLUTIONS OF SALTS

The table gives the difference in potential in hundredths of a volt between zinc in a normal solution of sulphuric acid and the metal named at the head of the columns in the solution named at the side. The signs given refer to the external difference of potential.

(Magnanini.)

Strength of the solution in gramme molecules per liter.	Difference of potential in centivolts.					
	Zinc	Cadmium.	Lead.	Tin.	Copper.	Silver.
0.5 Sulphuric acid	0.0	36.6	51.3	51.3	100.7	121.3
1.0 Sodium hydroxide	−32.1	19.5	31.8	0.2	80.2	95.8
1.0 Potassium hydroxide	−42.5	15.5	32.0	−1.2	77.0	104.0
0.5 Sodium sulphate	1.4	35.6	50.8	51.4	101.3	120.9
1.0 Potassium nitrate	11.8	31.9	42.6	31.1	81.2	105.7
1.0 Sodium nitrate	11.5	32.3	51.0	40.9	95.7	114.8
0.5 Potassium bichromate	72.8	61.1	78.4	68.1	123.6	132.4
0.5 Potassium sulphate	1.8	34.7	51.0	40.9	95.7	114.8
0.2 Potassium chlorate	15.−10.	39.9	53.8	57.7	105.3	120.9
1.0 Ammonium chloride	2.9	32.4	51.3	50.9	81.2	101.7
1.0 Sodium chloride	......	31.9	51.2	50.3	80.9	101.3
1.0 Potassium chloride	......	32.1	51.6	52.6	81.6	107.6

SPECIFIC RESISTANCE AND TEMPERATURE COEFFICIENT

For Metals

Resistance in ohms of unit length and unit cross-section at 0° C.

Metal.	Specific resistance.	Variation of resistance per ohm per dgeree C., at 20° C.
Aluminum	$2.6–3.0 \times 10^{-6}$	.0039
Antimony	35.4–45.8	.0039
Arsenic	33.3	.0042
Bismuth	108.0	.0045
Brass	8.5	.0010
Cadmium	6.2–7.0	.0042
Cobalt	9.8	.0033
Constantin	49.	−.00001
Copper, annealed	1.55–1.63	
hard drawn	1.61–1.68	
pure	1.54	.0041
Gas carbon	5000.	−.0005
German silver	30.	.00036
Gold	2.04–2.09	.0037
Iron, commercial	9.7–12.0	.0055
cast hard	97.8	
Lead	18.4–19.6	.0042
Magnesium	4.1–5.0	.0039
Manganin	42.	.00003
Mercury	94.	.0009
Nickel	10.7–12.4	.0060
Platinum	9.0–15.5	.0038
Platinum iridium	24.	.0012
Silver	1.5–1.7	.0040
Steel, hard	45.7	.0016
soft	15.9	.0042
Tantalum	14.5	.0027
Tin	9.53–11.4	.0043
Tungsten	7.0	.0039
Zinc	5.56–6.04	.0040

RESISTANCE OF ELECTROLYTES

Resistance of aqueous solutions of various salts and acids in ohms per centimeter cube for a temperature of 18° C.

(From observations by Kohlrausch.)

Salt.	Number of grams of salt in 100 grams solution.							
	5	10	15	20	25	30	40	50
Acetic acid	...	654.	616.	622.5	658.	714.	925.	1351.
Ammonium chloride	10.89	5.63	3.86	2.97	2.48			
Copper nitrate	27.4	15.7	11.7	9.82	9.17			
sulphate	52 9	31.2	23.7					
Hydrochloric acid	2.54	1 59	1.34	1.31	1.38	1.51	1.94	
Potassium iodide	29.5	14.7	.....	6.88	....	4.34	3.16	2.55
Silver nitrate	39 0	21.0	14.64	11.46	9.45	8.07	6.39	5.39
Sodium carbonate	22.2	14.2	12.0					
chloride	14 94	8.33	6.10	5.11	4.69			
hydroxide	5.08	3.20	2 89	3.06	3.68	4.95	8.61	
Sulphuric acid	4.79	2.55	1.84	1.53	1.39	1.35	1.47	1.85
Zinc chloride	20.70	13 75	...	10.96	....	10.80	11.83	15.87
sulphate	52.3	31.2	24.1	21.4	20.8	22.5		
(Concentration)	6 2	12 4	18.6	24.8	31.	37.2	43.4	
Nitric acid	3.2	1.84	1.45	1.30	1.28	1.32	1.43	
(Concentration)	8.4	12.6	16.8	21.	25.2	29.4	33.6	
Potassium hydroxide	3.67	2.66	2.19	1.96	1.85	1.84	1.91	

SAFE CARRYING CAPACITY OF COPPER WIRE

(From Collins' Design and Construction of Induction Coils, by permission.)

Brown & Sharpe gauge.	Diameter in mils.	Area in circular mils.	Number of amperes, exposed work.	Number of amperes, confined spaces.
18	40	1.624	5	3
17	45	2.048	6	4
16	51	2.583	8	6
15	57	3.257	10	8
14	64	4.106	16	12
13	72	5.178	19	14
12	81	6.530	23	17
11	91	8.234	27	21
10	102	10.380	32	25
9	114	13.090	39	29
8	128	16.510	46	33
7	144	20.820	56	39
6	162	26.250	65	45
5	182	33.100	77	53
4	204	41.740	92	63
3	229	52.630	110	75
2	258	66.370	131	88
1	289	83.690	156	105
0	325	105.500	185	125
00	365	133.100	220	150

RESISTANCE OF VARIOUS SUBSTANCES

Solids

Resistance in ohms per centimeter cube.

Substance.	Temp. ° C.	Resistance, ohms.
Celluloid	16	$2\text{–}80 \times 10^{9}$
Ebonite	....	$2\text{–}30 \times 10^{15}$
Fiber	....	$2\text{–}10 \times 10^{7}$
Glass	20	9×10^{13}
Ice	−1	5×10^{9}
Mica	....	$5\text{–}10 \times 10^{13}$
Paper variable with dryness	....	$1\text{–}1000 \times 10^{9}$
Paraffin	....	$3\text{–}300 \times 10^{16}$
Paraffin paper	....	$1\text{–}20 \times 10^{16}$
Porcelain	50	2×10^{15}
enameled	210	6×10^{9}
porous	20	2×10^{6}
Quartz crystal	20	1×10^{14}
fused	101	4×10^{11}
Rock salt	20	9×10^{16}
Slate	....	$2\text{–}4 \times 10^{8}$
Sulphur, prismatic	....	$70\text{–}390 \times 10^{13}$
octahedral	....	(resistance too high for measurement.)
Varnish	16	2×10^{12}
Wood dry	....	$.5\text{–}10 \times 10^{8}$
green	....	$5\text{–}10 \times 10^{3}$
Zirconium oxide	1200	1.2×10^{3}

Liquids

Resistance in ohms per centimeter cube.

Substance.	Temp. ° C.	Resistance, ohms.
Alcohol, ethyl	15	$.3 \times 10^{6}$
methyl	....	$.14 \times 10^{6}$
Oils, olive	....	5×10^{12}
paraffin	....	1×10^{16}
Petroleum	....	2×10^{16}
Water distilled	18	0.5×10^{6}

Fused Salts

(Poincaré.)

Substance.	Temp. ° C.	Resistance, ohms.
Calcium chloride	750	.862
Potassium bromide	750	.714
chlorate fused	355	2.20
Silver nitrate	350	.820
Sodium chloride fused	750	.294

THERMOELECTRIC POWER

The table gives the electromotive force in microvolts per degree difference in temperature between the two junctions, for various metals with lead. The temperature given is the mean temperature of the two junctions. A is the thermo-electric power at 0 ° C. and B the coefficient in the equation for the thermoelectric power at any temperature,

$$Q = A + Bt,$$

where t is the mean temperature of the two junctions. The thermoelectric power of any two metals in the table may be found by subtracting the value for the first from that of the second, a positive difference indicating that the current will flow from the cold to the hot junction in the second metal.

The sign of the values given is so chosen that if A is positive the current flows in the metal listed from the cold to the hot junction. When B is positive Q increases with the temperature.

(Principally from the Smithsonian Physical Tables.)

Metal.	A micro-volts.	B micro-volts per ° C.	Temp. ° C.	Thermo-electric power, micro-volts.	Neutral point.
Aluminum[1]	0.76	−0.0039	20	0.68	195
Antimony comm'l.-pressed wire[2]	.....	......	20	−6.0	
pure[3]	.....	−0.018	−100−+100	−1.49	
Argentan[1]	11.94	0.0506	20	12.95	−236
Arsenic[2]	.....	......	20	13.56	
Bismuth comm'l.-pressed wire[2]	.....	......	20	97.0	
pure pressed wire[2]	.....	......	20	89.0	
commercial[4]	.....	......	50	39.9	
Brass[5]	.....	−0.0026	0.260	−0.65	
Cadmium[1]	−2.63	−0.0424	20	−3.48	−62
Cobalt[2]	.....	......	20	22.	
Constantin	.....	......	50	+19.3	
Copper[1]	−1.34	−0.0094	20	−1.52	−143
commercial[2]	.....	......	20	−0.10	
German silver[3]	.....	+0.019	−100−+100	+10.7	
Gold[1]	−2.80	−0.0101	20	−3.0	−277
Iron[1]	−17.15	0.0482	20	−16.2	356
pianoforte wire[2]	.....	......	20	−17.5	
Magnesium[1]	−2.22	0.0094	20	−2.03	236
Manganin[3]	.....	0.003	−100−+100	1.12	
Mercury[2]	.....	......	20	0.413	
Nickel[4]	.....	......	50	15.50	
Paladium[1]	6.18	0.0355	20	6.9	−174
Platinum, pure[6]	.....	+0.011	0-200	+3.04	
Platinum-iridium alloys:					
85%Pt+15%Ir[1]	−7.90	−0.0062	20	−8.03	−1274
90%Pt+10%Ir[1]	−5.90	0.0133	20	−5.63	444
Selenium[2]	.....	......	20	−807.	
Silver[1]	−2.12	−0.0147	20	−2.41	−144
pure hard[2]	.....	......	20	−3.00	
Steel[1]	−11.27	0.0325	20	−10.62	347
Tellurium[2]	.....	......	20	−502.	
Tin, commercial[4]	.....	......	50	−0.33	
Tin[1]	0.43	−0.0055	20	0.33	78
Zinc[1]	−2.32	−0.0238	20	−2.79	−98

OBSERVERS: [1] Tait. [2] Matthiesen. [3] Dewar & Fleming. 1895. [4] Ed. Becquerel. [5] Steinmann. [6] Noll, 1894.

MAGNETIC CONSTANTS OF IRON

Permeability of Transformer Iron

Giving M, the total magneto motive force applied. M/l, the magneto motive force per unit length of iron circuit. B the total induction, B/a the induction per unit cross-section of iron, M/B, the magnetic reluctance of the iron circuit and Bl/Ma, the permeability; showing the typical relations of the magnetic constants for varying field.

(From Smithsonian Tables.)

M.	M/l.	B.	B/a.	Reluctance $M/B=K$.	Permeability $Bl/Ma = \mu$.
20	0.597	218×10^3	1406	0.917×10^{-4}	2360
40	1.194	587	3790	0.681	3120
60	1.791	878	5660	0.683	3180
80	2.338	1091	7040	0.734	2960
100	2.985	1219	7860	0.819	2640
120	3.582	1330	8580	0.903	2410
140	4.179	1405	9060	0.994	2186
160	4.776	1475	9510	1.090	2000
180	5.373	1532	9880	1.180	1850
200	5.970	1581	10200	1.270	1720
220	6.567	1618	10430	1.360	1590
260	7.761	1692	10910	1.540	1410

MAGNETIC PROPERTIES OF IRON AND STEEL

(From Gumlich, 1909.)

Sample.	Coercive force.	Residual B.	Maximum permeability.	B for $H=150$.	$4\pi I$ for saturation.
Electrolytic iron	2.83	11400	1850	19200	21620
The same annealed	0.36	10800	14400	18900	21630
Cast steel	1.51	10600	3550	18800	21420
The same annealed	0.37	11000	14800	19100	21420
Steel hardened	52.4	7500	110	11700	18000
Cast iron	11.4	5100	240	10400	16400
The same annealed	4.6	5350	600	11000	16800
Electrical iron in sheets annealed	1.30	9400	3270	18200	20500

SATURATION CONSTANTS FOR MAGNETIC SUBSTANCES

Substance.	Field intensity. (For saturation.)	Induced magnetization. (For saturation.)	Substance.	Field intensity. (For saturation.)	Induced magnetization. (For saturation.)
Cobalt	9000	1300	Nickel, hard	8000	400
Iron, wrought	2000	1700	annealed	7000	515
cast	4000	1200	Vicker's steel	15000	1600
Manganese steel	7000	200			

MAGNETIC SUSCEPTIBILITY OF VARIOUS SUBSTANCES

Metals

Magnetic susceptibility or the ratio of the magnetic moment per unit volume to the magnetizing field is given for various substances. The value is negative for diamagnetic bodies, positive for paramagnetic bodies.

(C. G. S. Electromagnetic units.)

Substance.	Temp. °C.	Susceptibility (vacuum = 0).	Observer.
Aluminum	.....	-1.8×10^{-6}	
Antimony	.....	-4.6	Curie, 1895
Bismuth	.....	-13.3	Curie, 1895
Copper	.....	-1.33	Becquerel, 1855
Gold	.....	$-4\ 5$	Hanriot & Raoult, 1911
Lead	.....	-1.21	Becquerel
Mercury	15	-2.1	St. Mayer
Platinum	.....	$+29.0$	J. Königsberger, 1898
Selenium	20	-1.54	Curie, 1895
Silver	.....	-1.8	Becquerel, 1855
Tellurium	20	-1.94	Curie, 1895
Zinc	.....	-1.16	Owen, 1912
Iron annealed	.....	$+37.4 \times 10^{1}$	For weak fields
Nickel	.....	$+4. \times 10^{1}$	For H = 100 C. G. S.
Steel tempered	.....	$+3.4 \times 10^{1}$	For weak fields

Inorganic Compounds

Substance.	Temp. °C.	Susceptibility (vacuum = 0).	Observer.
Boric acid	.....	-0.88×10^{-6}	Meslin, 1906
Cobalt sulphate ($7H_2O$)	.....	$+76.3$	Meslin, 1906
Copper sulphate ($5H_2O$)	.....	$+13.4$	Mlle. Feytis, 1911
Ferric chloride	.....	$+287.$	Meslin, 1906
Ferrous sulphate ($7H_2O$)	.....	$+95.3$	Meslin, 1906
Glass	.....	-0.15	Faraday, 1853
Nickel sulphate ($7H_2O$)	.....	$+37.$	Meslin, 1906
Potassium bichromate	.....	$+0.36$	Meslin, 1906
Potassium chloride	18	-1.09	Curie, 1895
Potassium ferrocyanide	.....	$+16.0$	Meslin, 1906
Quartz	20	-1.20	J. Königsberger
Sodium chloride	22	-1.02	Meslin, 1906

Liquids

Substance.	Temp. °C.	Susceptibility (vacuum = 0).	Observer.
Acetic acid	.....	-0.61	Meslin, 1906
Alcohol, ethyl	.....	-0.65	Meslin, 1906
Benzene	.....	-0.69	Meslin, 1906
Chloroform	.....	-0.86	Meslin, 1906
Ether	.....	-0.61	Meslin, 1906
Glycerine	.....	-0.81	Meslin, 1906
Sulphuric acid	.....	-0.77	Quincke, 1885
Water	20	-0.72	Piccard, 1912

VARIATION OF RESISTANCE DUE TO A MAGNETIC FIELD

Bismuth

The table shows the proportional values of the resistance for values of the magnetic field from 0 to 35,000 and for different temperatures. The resistance at 0° C. and H = 0 is taken as 1.

Proportional values of resistance.

(From Smithsonian Tables.)

H. Gauss.	−192°	−135°	−100°	−37°	0°	+18°	+60°	+100°	+183°
0	0.40	0.60	0.70	0.88	1.00	1.08	1.25	1.42	1.79
2000	1.16	0.87	0.86	0.96	1.08	1.11	1.26	1.43	1.80
4000	2.32	1.35	1.20	1.10	1.18	1.21	1.31	1.46	1.82
6000	4.00	2.06	1.60	1.29	1.30	1.32	1.39	1.51	1.85
8000	5.90	2.88	2.00	1.50	1.43	1.42	1.46	1.57	1.87
10000	8.60	3.80	2.43	1.72	1.57	1.54	1.54	1.62	1.89
12000	10.8	4.76	2.93	1.94	1.71	1.67	1.62	1.67	1.92
14000	12.9	5.82	3.50	2.16	1.87	1.80	1.70	1.73	1.94
16000	15.2	6.95	4.11	2.38	2.02	1.93	1.79	1.80	1.96
18000	17.5	8.15	4.76	2.60	2.18	2.06	1.88	1.87	1.99
20000	19.8	9.50	5.40	2.81	2.33	2.20	1.97	1.95	2.03
25000	25.5	13.3	7.30	3.50	2.73	2.52	2.22	2.10	2.09
30000	30.7	18.2	9.8	4.20	3.17	2.86	2.46	2.28	2.17
35000	35.5	20.35	12.2	4.95	3.62	3.25	2.69	2.45	2.25

Various Metals

The table gives the per cent. change in the resistance due to a field of 10,000 gauss with respect to the value at 0° C. and H = 0.

(Grumach.)

Metal.	Per cent. change.	Metal	Per cent. change.
Cadmium	+0.03	Palladium	+0.001
Cobalt	−0.53	Platinum	+0.0005
Copper	+0.004	Silver	+0.004
Gold	+0.003	Tantalum	+0.0003
Lead	+0.0004	Tin	+0.002
Nickel	−1.4	Zinc	+0.01

INTERNAL RESISTANCE OF VARIOUS VOLTAIC CELLS

The internal resistance is subject to large variations; the values given can be considered only approximate.

Cell.	Resistance, ohms.	Cell.	Resistance, ohms.
Edison-Lalande	0.03	Grove	0.1–0.2
Daniell	0.85	Bunsen	0.1–0.2
Gravity	1–5	Bichromate	0.08–0.40
Silver chloride	4.	Storage	0.004–0.02
Dry cell	0.2–1.0	Clark standard	20–50
Leclanché	0.4–0.2	Weston standard	20–50

HALL EFFECT

If a strip of metal of thickness t, in which a current i is flowing (longitudinally) is subjected to a transverse magnetic field H, a difference of potential E is produced at opposite points at the side of the strip. $E = R \times Hi/t$ where R is a constant specific with different metals and E, H, i and t in C. G. S. units. The table gives values obtained at ordinary room temperatures, 18–24° C. If the value of R is independent of the field, or nearly so, the field intensity is not given. The positive sign indicates that if a strip of metal were considered to be in the plane of this page with its long axis horizontal, the primary current flowing from left to right and the magnetic field directed away from the observer, normal to the plane of the strip, the upper edge of the strip would be at a higher potential than the lower.

Substance.	Field strength, gausses.	*R.*	Observer.
Aluminum	......	−.00038	Von Ettinghausen & Nernst, 1886
Antimony	1750	+0.219	Barlow, 1903
Bismuth	1650	−10.27	Von Ettinghausen & Nernst, 1886
Bismuth	11100	−4.95	Von Ettinghausen & Nernst, 1886
Cadmium	......	+.00055	Von Ettinghausen & Nernst, 1886
Carbon	......	−.17	Von Ettinghausen & Nernst, 1886
Cobalt	3463	+.24	Hall, 1885
Copper	......	−.00052	Hall, 1885
Gold	......	−.00066	Hall, 1885
Iron	6290	+.0108	Zahn, 1904
Lead	......	.00009	Von Ettinghausen & Nernst, 1886
Magnesium	......	−.00094	Von Ettinghausen & Nernst, 1886
Nickel	10620	−.0047	Zahn, 1904
Platinum	......	−.00024	Von Ettinghausen & Nernst, 1886
Silver	......	−.00083	Von Ettinghausen & Nernst, 1886
Tellurium	......	+530.	Von Ettinghausen & Nernst, 1886
Tin	......	−.00004	Von Ettinghausen & Nernst, 1886
Zinc	......	+.00033	Barlow, 1903

ELECTROCHEMICAL EQUIVALENTS

Grams per coulomb.

Element.	Valence.	Equiv.	Element.	Valence.	Equiv.
Aluminum	3	$.0936 \times 10^{-3}$	Iron	3	$.1929 \times 10^{-3}$
Antimony	3	.4153	Lead	2	1.0731
Antimony	5	.2492	Magnesium	2	.1260
Bismuth	3	.7185	Mercury	1	2.0788
Cadmium	2	.5824	Mercury	2	1.0394
Chromium	3	.1796	Nickel	2	.3040
Cobalt	2	.3055	Oxygen	2	.0829
Copper	1	.6588	Platinum	2	1.0104
Copper	2	.3294	Silver	1	1.1180
Gold	3	.6812	Tin	2	.6166
Hydrogen	1	.0105	Tin	4	.3083
Iron	2	.2893	Zinc	2	.3387

MAGNETIC INCLINATION OR DIP AND HORIZONTAL INTENSITY

The mean or limiting values are given for the territory covered by the State named. The horizontal intensity is given in gausses. The table is compiled from the results of the U. S. Coast and Geodetic Survey for 1911 and 1912.

State.	Dip, degrees.		Horizontal intensity.	
Alabama	62.	to 66.	.23	to .26
Alaska	67.	74.	.16	.21
Arizona	59.		.27	
Arkansas	63.	65.	.24	.25
California	58.	62.	.25	.27
Colorado	67.	68.	.22	.23
Connecticut	72.	73.	17	.18
Delaware	70.	71.5	19	.20
Florida	57.	58.	27	.29
Georgia	62.	66.	.23	.26
Hawaii	39.		.29	
Idaho	69.		.21	
Indiana	69.	72.	.18	.21
Iowa	71.	73.	.18	.20
Kansas	67.	69.	.21	.23
Kentucky	68.	70.	.20	.22
Maine	74.	76.	.14	.16
Maryland	70.5		.20	
Massachusetts	73.		.17	
Michigan	73.	76.	.15	.18
Mississippi	61.	66.	.24	.26
Missouri	67.	71.	.20	.22
Montana	70.	72.	.18	.20
Nebraska	70.	71.	.20	
New Hampshire	73.	74.	.16	.17
New Jersey	71.		.19	
New Mexico	63.	65.	.24	.25
New York	74.		.16	.17
North Carolina	66.	68.	.21	.23
North Dakota	74.	77.	.15	.16
Ohio	71.	73.	.18	.20
Oklahoma	63.	67.	.23	.25
Oregon	68.	69.	.21	
Pennsylvania	71.	72.	.18	.19
Philippines	0.	23.	.37	.39
Porto Rico	49.	50.	.29	.30
South Carolina	66.	67.	.23	
South Dakota	71.	74.	.17	.19
Tennessee	66.	68.	.22	.23
Texas	57.	63.	.25	.29
Utah	66.	67.	.22	.23
Vermont	73.	75.	.16	.17
Virginia	68.	70.	.20	.21
Washington	71.		.19	
West Virginia	70.5		.20	
Wisconsin	74.	76.	.15	.17
Wyoming	68.	72.	.19	.22

MAGNETIC DECLINATION

An annual decrease in declination is indicated by the negative sign, an increase by the positive.

(From U. S. Coast and Geodetic Survey)

State.	Station.	Magnetic declination in degrees and tenths.					Ann. Chge. (1910).
		1870	1880	1890	1900	1910	
Ala.	Montgomery	4.5 E	3.9 E	3.2 E	2.8 E	2.9 E	−.012
Alaska	Sitka	29.0 E	29.3 E	29.5 E	29.7 E	30.2 E	
	Kodiak	25.6 E	25.1 E	24.7 E	24.4 E	24.1 E	
	Unalaska	20.1 E	19.6 E	19.0 E	18.3 E	17.5 E	
	St. Michael	....	24.7 E	23.1 E	22.1 E	21.4 E	
Ariz.	Holbrook	13.8 E	13.7 E	13.4 E	13.5 E	13.9 E	+.072
	Prescott	13.7 E	13.6 E	13.5 E	13.7 E	14.3 E	+.077
Ark.	Little Rock	8.2 E	7.6 E	7.0 E	6.6 E	6.9 E	+.023
Cal.	Los Angeles	14.4 E	14.6 E	14.6 E	14.9 E	15.5 E	+.083
	San José	17.3 E	17.5 E	17.5 E	17.8 E	18.5 E	+.075
Cal.	Redding	18.1 E	18.2 E	18.3 E	18.6 E	19.3 E	+.075
Colo.	Pueblo	13.8 E	13.5 E	13.0 E	12.9 E	13.3 E	+.050
	Glenwood Sp.	16.3 E	16.1 E	15.7 E	15.6 E	16.1 E	+.062
Conn.	Hartford	8.7 W	9.4 W	9.8 W	10.4 W	11.0 W	+.097
Del.	Dover	4.7 W	5.3 W	5.9 W	6.4 W	7.0 W	+.080
D. C.	Washington	2.4 W	3.0 W	3.6 W	4.2 W	4.7 W	+.075
Fla.	Jacksonville	3.1 E	2.4 E	1.8 E	1.3 E	1.2 E	−.033
	Tampa	3.9 E	3.3 E	2.8 E	2.3 E	2.0 E	−.013
Ga.	Macon	3.9 E	3.2 E	2.6 E	2.1 E	2.0 E	−.033
Hawaii	Honolulu	9.5 E	9.8 E	10.1 E	10.4 E	10.6 E	
Idaho	Pocatello	17.8 E	17.9 E	17.7 E	17.8 E	18.4 E	+.067
	Boise	18.6 E	18.7 E	18.6 E	18.8 E	19.4 E	+.075
Ill.	Bloomington	5.4 E	4.7 E	4.1 E	3.6 E	3.4 E	−.013
Ind.	Indianapolis	3.2 E	2.6 E	2.0 E	1.4 E	1.1 E	−.030
Ia.	Des Moines	9.7 E	9.1 E	8.4 E	7.9 E	8.1 E	+.017
Kans.	Emporia	11.2 E	10.7 E	10.1 E	9.8 E	10.1 E	+.030
	Ness City	12.2 E	11.9 E	11.4 E	11.1 E	11.4 E	+.040
Ky.	Lexington	2.5 E	1.9 E	1.2 E	0.7 E	0.5 E	−.033
	Princeton	5.6 E	5.0 E	4.3 E	3.8 E	3.7 E	−.017
La.	Alexandria	8.0 E	7.4 E	6.9 E	6.6 E	6.8 E	+.030
Me.	Eastport	18.2 W	18.6 W	18.7 W	19.0 W	19.4 W	+.100
	Portland	12.8 W	13.4 W	13.9 W	14.4 W	14.8 W	+.100
Md.	Baltimore	3.8 W	4.4 W	5.0 W	5.6 W	6.1 W	+.075
Mass.	Boston	11.0 W	11.5 W	12.0 W	12.6 W	13.1 W	+.100
	Pittsfield	9.3 W	10.0 W	10.4 W	11.0 W	11.5 W	+.097
Mich.	Marquette	4.6 E	3.8 E	3.0 E	2.3 E	2.0 E	−.027
	Lansing	2.1 E	1.3 E	0.5 E	0.0 E	0.4 E	+.040
Minn.	Northome	10.0 E	9.3 E	8.6 E	8.0 E	8.1 E	+.017
	Mankato	10.9 E	10.4 E	9.5 E	9.0 E	9.1 E	+.020
Miss.	Jackson	7.5 E	6.9 E	6.4 E	6.0 E	6.2 E	+.017
Mo.	Sedalia	9.4 E	8.7 E	8.0 E	7.6 E	7.9 E	+.020
Mont.	Forsyth	18.6 E	18.4 E	17.9 E	17.8 E	18.3 E	+.050
	Helena	19.8 E	19.6 E	19.4 E	19.5 E	20.0 E	+.062
Nebr.	Hastings	11.7 E	11.2 E	10.5 E	10.2 E	10.5 E	+.033
	Alliance	15.3 E	14.8 E	14.3 E	14.2 E	14.5 E	+.043

MAGNETIC DECLINATION (Continued)

An annual decrease in declination is indicated by the negative sign and an increase by the positive.

(From U. S. Coast and Geodetic Survey.)

State.	Station.	Magnetic declination in degrees and tenths. 1870	1880	1890	1900	1910	Ann. Chge, (1910)
Nevada...	Elko...........	17.7 E	17.7 E	17.6 E	17.8 E	18.3 E	+.077
	Hawthorne......	16.9 E	17.0 E	17.0 E	17.3 E	17.8 E	+.083
N. H......	Hanover.........	11.1 W	11.6 W	12.0 W	12.5 W	13.0 W	+.100
N. J......	Trenton........	6.0 W	6.7 W	7.2 W	7.8 W	8.4 W	+.082
N. Mex...	Santa Rosa.....	12.7 E	12.5 E	12.1 E	12.0 E	12.4 E	+.060
N. Mex...	Laguna.........	13.6 E	13.4 E	13.0 E	13.0 E	13.5 E	+.062
N. Y......	Albany.........	9.1 W	9.8 W	10.2 W	10.8 W	11.4 W	+.093
	Elmira.........	5.4 W	6.3 W	7.0 W	7.6 W	8.1 W	+.075
N. C......	Newbern........	1.0 W	1.6 W	2.2 W	2.8 W	3.3 W	+.057
	Salisbury.......	1.5 E	0.8 E	0.2 E	0.4 W	0.7 W	+.047
N. Dak...	Jamestown......	14.0 E	13.5 E	12.7 E	12.4 E	12.8 E	+.030
	Dickinson.......	17.4 E	17.0 E	16.4 E	16.2 E	16.6 E	+.040
Ohio......	Columbus.......	1.2 E	0.6 E	0.0 E	0.7 W	1.1 W	+.047
Okla......	Okmulgee.......	9.8 E	9.4 E	8.8 E	8.5 E	8.9E	+.033
	Enid...........	10.9 E	10.5 E	9.9 E	9.7 E	10.1 E	+.043
Oregon....	Sumpter........	20.0 E	20.2 E	20.2 E	20.4 E	21.0 E	+.077
	Detroit.........	20.1 E	20.4 E	20.5 E	20.8 E	21.5 E	+.080
Penn......	Philadelphia.....	5.5 W	6.3 W	6.8 W	7.4 W	8.0 W	+.083
	Altoona.........	3.1 W	3.8 W	4.5 W	5.1 W	5.6 W	+.067
P. R......	San Juan.......	....	....	....	1.0 W	2.0 W	
R. I......	Newport........	10.3 W	10.8 W	11.3 W	11.9 W	12.4 W	+.100
S. C......	Columbia.......	2.1 E	1.4 E	0.8 E	0.2 E	0.1 W	+.043
S. D......	Huron..........	12.6 E	12.1 E	11.4 E	11.1 E	11.4 E	+.030
	Rapid City......	16.3 E	15.8 E	15.3 E	15.1 E	15.4 E	+.042
Tenn.....	Chattanooga....	3.3 E	2.6 E	2.0 E	1.5 E	1.3 E	−.033
Tenn.....	Huntington.....	6.1 E	5.5 E	4.9 E	4.4 E	4.3 E	−.008
Texas.....	Houston........	8.9 E	8.5 E	7.9 E	7.7 E	8.1 E	+.042
	San Antonio.....	9.6 E	9.3 E	8.9 E	8.7 E	9.1 E	+.050
	Pecos...........	11.0 E	10.8 E	10.4 E	10.3 E	10.7 E	+.060
	Floydada.......	11.2 E	10.9 E	10.4 E	10.3 E	10.7 E	+.052
Utah......	Salt Lake City ..	16.7 E	16.5 E	16.3 E	16.5 E	17.0 E	+.070
Vermont ..	Rutland........	10.6 W	11.2 W	11.6 W	12.1 W	12.7 W	+.100
Va........	Richmond......	1.8 W	2.5 W	3.1 W	3.7 W	4.2 W	+.067
	Lynchburg......	0.5 W	1.2 W	1.8 W	2.4 W	2.8 W	+.057
Wash.....	Wilson Creek...	21.9 E	21.9 E	22.1 E	22.4 E	22.9 E	+.075
Wash.....	Seattle.........	22.1 E	22.3 E	22.6 E	23.0 E	23.5 E	+.083
W. Va....	Charleston......	0.2 W	0.9 W	1.5 W	2.1 W	2.6 W	+.057
Wis.......	Madison........	7.2 E	6.4 E	5.6 E	5.0 E	4.9 E	−.017
Wyo......	Douglas........	16.0 E	15.8 E	15.4 E	15.3 E	15.7 E	+.053
	Green River.....	17.0 E	16.9 E	16.6 E	16.6 E	17.0 E	+.060

LIGHT

PHOTOMETRIC STANDARDS

VALUE OF VARIOUS STANDARDS IN INTERNATIONAL CANDLES

Standard Pentane Lamp, burning pentane......	10.0 candles
Standard Hefner Lamp, burning amyl acetate....	0.9 "
Standard Carcel Lamp, burning colza oil.........	9.6 "
Standard English Sperm Candle, about..........	1.0 "

The *Carcel unit* is the horizontal intensity of the carcel lamp, burning 42 grams of colza oil per hour. For a consumption between 38 and 46 grams per hour the intensity may be considered proportional to the consumption.

The *Hefner unit* is the horizontal intensity of the Hefner lamp burning amyl acetate, with a flame 4 cm. high. If the flame is l mm. high, the intensity $I=1+0.027(l-40)$.

STANDARD CANDLES

The horizontal intensity may be considered proportional to the rate of consumption of material if the variation is small.

	French.	English.	German.
Material.......	2 pts. stearic acid 1 pt. palmitic acid	Spermaceti	Paraffin
Temp. of fusion.	54° C.	44.4–46°.1 C.	55° C.
Wick (cotton)...	81 threads	54 to 63 threads	24 to 25 threads
Height of flame..	5.24 cm.	4.5 cm.	5 cm.
Rate of consumption of material	10 g. per hr.	7.78 g. per hr.	7.7 g. per hr.
Horizontal intensity in Internat. candles	1.34	1.05	1.11

MEAN HORIZONTAL CANDLE POWER OF VARIOUS LIGHT SOURCES

GIVEN IN INTERNATIONAL CANDLES.

(Lux, 1907.)

Source.	Total power consumed in watts.	Mean horizontal candle power.	Efficiency in watts per candle (spherical)
Acetylene flame	96	6.9	17.7
Electric arcs:			
Carbon, open air, continuous current	435	171	0.92
alternating current	181	98	2.27
Flaming arc, yellow	350	816	0.34
Mercury arc, uviol tube	199	393	0.64
quartz tube	691	3060	0.25
Incandescent electric, carbon filament	98	28.3	4.54
tantalum filament	44	31.1	1.83
tungsten filament	38	32.7	1.59
tungsten filament, gas filled	1000	1670	0.66
Incandescent gas mantle, vertical	717	96.3	8.9
inverted	571	96.3	7.7
Nernst lamp	181	108	2.12

PRIMARY COLOR SENSATIONS PRODUCED BY VARIOUS LIGHT SOURCES

The relative values of the excitation of the three primary sensations are given.

(Ives, 1911.)

Source.	Red.	Green.	Blue.
Black body at 5000° absolute	33	33	33
Blue sky	29	30	41
Clouded sky	35	34	31
Sun	38	37	25
Hefner lamp	54	40	6
Acetylene flame	49	40	11
Incandescent carbon filament	51	41	8
Tungsten filament	48	41	11
Nernst filament	49	40	11
Electric arc, carbon	41	36	23
Mercury arc	29	30	41
Flaming arc	52	37.5	10.5
Incandescent gas mantle, thorium with 0.25 part in 100 of cerium	42	41	17

INTRINSIC BRILLIANCY OF SURFACE INTENSITY OF LIGHT SOURCES

GIVEN IN INTERNATIONAL CANDLES PER SQUARE CENTIMETER.

Sources.	Surface intensity.	Observer.
Electric arc:		
current of 10 amperes	16000	Blondel, 1897
current of 25 amperes	19500	Blondel, 1897
current of 250 amperes	30000	Rey & Blondel, 1902
Flaming arc	4000	
Flames, candle	0.4–0.6	
petroleum lamp, round wick	3.3	Stockhausen, 1910
petroleum lamp, flat wick	.67	Stockhausen, 1910
gas, argand burner	1.14	Stockhausen, 1910
acetylene, flat flame	5.6	Stockhausen, 1910
Incandescent electric:		
filament of carbon (3.3 watts per candle)	75.	Blondel, 1911
filament of tungsten (1.2 watts per candle)	150.	Blondel, 1911
Nernst	350–470	Ives & Luckiesch, '11
Gas mantle	4.8–6.7	Ives & Luckiesch
Mercury arc	2.5	Ives & Luckiesch
Moon	0.4	Pickering, 1908
Star (Algol)	840000	Nordmann, 1910
Sun at zenith	160000	Palaz, 1893

WAVE LENGTHS OF VARIOUS RADIATIONS

	Microns
Röntgen (X) rays	0.0001
Shortest ultra-violet radiation	0.103
Shortest ultra-violet radiation in the solar spectrum (limited by atmospheric absorption)	0.292
Limit of the visible spectrum	0.390
Violet, wave length best representing the color	0.410
Wave lengths included	0.390–0.422
Blue, representative	0.470
Includes	0.422–0.492
Green, representative	0.520
Includes	0.492–0.535
Maximum visual intensity, about	0.535
Yellow, representative	0.580
Includes	0.535–0.586
Orange, representative	0.600
Includes	0.586–0.647
Red, representative	0.650
Includes	0.647–0.810
Limit of the visible spectrum	0.810
Limit of the solar spectrum	5.300
Infra-red (heat waves)	
Includes	0.810–314.00
Shortest measured Hertzian wave	4000.
Used for wireless telegraphy	100–5000 meters

VARIATION IN THE SENSITIVENESS OF THE EYE WITH THE WAVE LENGTH

For Low Intensities

(König.)

Wave length...	.410	.430	.450	.470	.490	.510	.530	.550	.570	.590	.610
Mean sensitiveness........	0.02	0.06	0.23	0.49	0.81	1.00	0.81	0.49	0.22	0.077	0.026

WAVE LENGTHS OF THE FRAUNHOFER LINES

Sun's Spectrum

At 15° C. and 76 cm. pressure. Wave length in microns (Fabry and Buisson system).

Line.	Due to	Wave length in Microns.	Line.	Due to	Wave length in microns.
U	Fe	2947.9	*h*	H	4101.9
t	Fe	2994.4	*g*	Ca	4226.7
T	Fe	3020.7	*G*	Ca	4307.7
s	Fe	3047.6		Fe	4307.9
S	Fe	3099.9	*G*	H	4340.5
	Fe	3100.0	*F*	H	4861.4
	Fe, Mn	3100.3	b_4	Mg	5167.3
	Fe, Ti	3100.7	b_2	Mg	5172.7
R	Ca	3179.3	b_1	Mg	5183.6
Q	Fe	3286.8	*E*	Fe	5269.6
P	Ti	3361.2	D_2	Na	5890.0
O	Fe	3440.6	D_1	Na	5895.9
	Fe	3441.0	*C*	H	6562.8
N	Fe	3581.2	*B*	O	6867.2
M	Fe	3719.9	*A*	O	7593.8
L	Fe, C	3820.4	*Z*	.....	8228.5
K	Ca	3933.7	*Y*	.....	8990.0
H	Ca	3968.5			

WAVE LENGTHS FOR SPECTROSCOPE CALIBRATION

Source.	Wave length.	Source.	Wave length.
Potassium flame..........	0.7699μ	*F*, solar..................	0.5270μ
Potassium flame..........	0.7666	b_1, solar or magnesium flame	0.5184
B, solar................	0.6867	b_2, solar or magnesium flame	0.5173
Lithium flame............	0.6708	*F*, solar or hydrogen tube...	0.4867
C, solar or hydrogen tube..	0.6563	Strontium flame...........	0.4608
D_1, solar or sodium flame..	0.5896	*G*, solar or hydrogen tube...	0.4308
D_2, solar or sodium flame..	0.5893	H_1, solar..................	0.3969
Thallium flame...........	0.5351	H_2, solar..................	0.3934

WAVE LENGTH OF PRINCIPAL LINES OF VARIOUS ELEMENTS

Solids

Wave lengths of the most prominent lines in microns. The letters a, s and f after a wave length indicate its occurrence as a strong line in the arc, spark or flame spectrum respectively.

Aluminum	.3082	a, s	Caesium	.4555	a, f
	.3092	a, s		.4593	a, f
	.3587	s		.6723	a
	.3944	a, s		.6974	a
	.3961	a, s	Calcium	.3934	a, s
	.5697	s		.3969	a, s
	.5723	s		.4227	a, s, f
Antimony	.3268	s	Calcium chloride in the Bunsen flame also gives lines not due to calcium	.5517	
	.6005	s		.5543	
	.6079	s		.6181	
	.6130	s		.6202	
Arsenic	.2745	s		.6265	
	.2861	s	Cerium	.4012	s
	.3923	s		.4134	s
	.4037	s		.4150	s
Barium	.3891	s		.4165	s
	.4131	s		.4187	s
	.4554	a, s		.4297	s
	.4934	a, s		.4527	s
	.5535	a, s, f		.4628	s
	.5853	a, s		.5274	s
	.6141	a, s		.5353	s
	.6497	a, s	Chromium*	.4255	a, s
Barium chloride in the Bunsen flame gives other lines not due to barium	.5136			.4275	a, s
	.5242			.4290	a, s
	.5313			.4559	s
Bismuth	.3596	s		.4588	s
	.4723	a, s		.5205	a, s
	.4994	s		.5206	a, s
Cadmium	.3611	a, s		.5209	a, s
	.4678	a, s		.5410	a
	.4800	a, s	Cobalt†	.3846	a, s
	.5086	a, s		.3873	a, s
	.5338	s		.3894	a, s
	.5378	s		.4531	a
	.6439	a, s			

* More than twenty fairly prominent lines occur in the spark spectrum of chromium having wave lengths from .2763 to .3606μ.

† A large number of lines occur in the arc and spark spectrum of cobalt having wave lengths less than .3600 (ultraviolet).

WAVE LENGTH OF PRINCIPAL LINES OF VARIOUS ELEMENTS (Continued)

Solids (Continued)

Cobalt (Cont.)	.4581	a	Iron*	.4046	a, s
	.4780	a, s		.4064	a, s
	.4793	a, s		.4071	a, s
	.4814	a, s		.4118	a
	.4840	a, s		.4132	a, s
	.4868	a, s		.4134	a
				.4143	a
Copper	.3248	a		.4144	a, s
	.3274	a		.4187	a, s
	.4023	a		.4188	a, s
	.4063	a		.4191	a
	.5106	a, s		.4198	a, s
	.5153	a, s		.4199	a, s
	.5218	a, s		.4202	a, s
	.5700	a		.4227	a, s
	.5782	a, s		.4234	a, s
Gold	.2428	a, s		.4236	a, s
	.2676	a, s		.4250	a, s
	.2802	s		.4251	a, s
	.3898	s		.4261	a, s
	.4065	s		.4272	a, s
	.4315	s		.4282	a, s
	.6278	s		.4294	a, s
				.4299	a, s
Iodine (spark)	.5159			.4308	a, s
	.5244			.4315	a
	.5339			.4326	a, s
	.5349			.4337	a
	.5408			.4384	a, s
	.5448			.4405	a, s
	.5471			.4415	a, s
	.5631			.4476	a
	.5686			.4528	a, s
	.5716			.4655	a, s
	.5741			.4736	a
	.5766			.4892	a
	.5781			.4921	a, s
	.5961			.4957	a, s
				.5139	a, s
Iridium	.3606	s		.5167	a, s
	.3653	s		.5192	a, s
	.3675	s		.5227	a, s
	.3800	s		.5233	a, s
	.3903	s		.5267	a, s
	.4400	a, s		.5270	a, s

* The ultraviolet spectrum of iron shows over 100 lines of intensity comparable with those listed above.

WAVE LENGTH OF PRINCIPAL LINES OF VARIOUS ELEMENTS (Continued)

Solids (Continued)

Iron (Cont.).....	.5284	a, s
	.5302	a, s
	.5324	a
	.5328	a
	.5372	a
	.5397	a
	.5406	a
	.5447	a
	.5455	a
	.5570	a
	.5573	a
	.5587	a
	.5616	a
	.5659	a
	.5763	a
	.5862	a
	.5930	a
	.6065	a
	.6137	a
	.6138	a
	.6192	a
	.6231	a
	.6253	a
	.6302	a
	.6318	a
	.6337	a
	.6400	a
	.6495	a
	.6546	a
	.6593	a
Lead*...........	.3640	a, s
	.3684	a, s
	.3740	a, s
	.3786	s
	.3854	s
	.4058	a, s
	.4245	s
	.4387	s
	.5374	s
	.5547	s
	.5608	s
	.6657	s
Lithium.........	.4132	a
Lithium (Cont.)..	.4602	a, s
	.6104	a
	.6708	a, s, f
Mercury.........	.2537	a
	.2967	a, s
	.3022	a
	.3023	s
	.3126	a, s
	.3132	a, s
	.3341	a, s
	.3650	a, s
	.3654	a, s
	.3663	a, s
	.3984	s
	.4046	a, s
	.4078	a, s
	.4358	a, s
	.5426	s
	.5461	a, s
	.5770	a, s
	.5791	a, s
	.5804	s
Magnesium.......	.2796	a, s
	.2803	a, s
	.2852	a, s, f
	.3097	a, f
	.3829	a, s, f
	.3832	a, s, f
	.3838	a, s, f
	.4481	s
	.5173	a, s
	.5183	a, s
Manganese......	.3807	a, s
	.4031	a, s
	.4033	a
	.4035	a
	.4042	a
	.4754	a
	.4784	a
	.4824	a, s
	.6014	a, s
	.6017	a, s
	.6022	a, s

* The arc and spark spectra of lead include a large number of lines in the ultraviolet not given above.

WAVE LENGTH OF PRINCIPAL LINES OF VARIOUS ELEMENTS (Continued)

Solids (Continued)

Molybdenum	.3635	s
	.3688	s
	.3798	a, s
	.3864	a, s
	.3903	a, s
	.3961	s
	.5506	a, s
	.5533	a, s
	.5570	a, s
	.6030	s
Nickel	.4714	a, s
	.4855	a, s
	.4866	a, s
	.4873	s
	.5035	a, s
	.5081	a
	.5477	a
	.5893	s
Osmium	.3753	s
	.4067	s
	.4136	s
	.4212	s
	.4261	s
	.4294	s
	.4421	s
Platinum	.3687	s
	.3923	s
	.4552	s
	.5228	a, s
	.5301	s
	.5369	s
Potassium	.3447	a, s, f
	.4044	a, s, f
	.6911	a
	.6939	a
	.7665	a, s, f
	.7699	a, s, f
Radium	.3650	s
	.3815	s
	.4341	s
	.4436	s
	.4533	s
	.4683	s
Radium (Cont.)	.4826	s, f
	.5661	s
	.5814	s
band .6130–	.6330	f
	.6349	f
band .6530–	.6700	f
Rubidium	.4202	a, s, f
	.4215	a, s, f
	.6207	a, f
	.6298	a, s, f
	.7806	a, f
	.7811	a
	.7950	a, f
Selenium	.4606	s
	.4840	s
	.4842	s
	.4972	s
	.4993	s
	.5094	s
	.5142	s
	.5176	s
	.5225	s
	.5270	s
	.5305	s
Silicon	.2516	a, s
	.2881	a, s
Silver	.3281	a, s
	.3383	a, s
	.4055	a
	.4212	a
	.5209	a, s
	.5466	a, s
Sodium	.3302	a, s, f
	.3303	a, s, f
	.5683	a
	.5688	a
	.5890	a, s, f
	.5896	a, s, f
	.6154	a
	.6161	a
Strontium	.4078	a, s
	.4216	a, s
	.4607	a, s, f

WAVE LENGTH OF PRINCIPAL LINES OF VARIOUS ELEMENTS (Continued)

SOLIDS (Continued)

Strontium compounds, chloride, nitrate, etc., give other bands not due to strontium	.6032	
	.6060	
	.6351	
	.6464	
	.6597	
	.6664	
	.6694	
Sulphur	.4465	s
	.4486	s
	.4525	s
	.4552	s
	.5021	s
	.5033	s
	.5201	s
	.5215	s
	.5320	s
	.5343	s
	.5605	s
	.5640	s
	.6290	s
Tantalum	.3906	s
	.4059	s
	.4080	s
	.4101	s
	.4124	s
Thallium	.2918	a
	.3230	a
	.3519	a, s
	.3529	a
	.3776	a, s, f
	.4737	s
	.5351	a, s, f
Thorium	.3221	s
	.3272	s
	.3291	s
	.3301	s
	.3314	s
	.3508	s
	.3539	s
	.4019	s
	.4382	s
	.4391	s
	.4555	s
Tin	.3801	s
	.4525	a, s
	.5564	s
	.5589	s
	.5632	a, s
	.5799	s
	.6453	s
Tungsten	.4843	s
	.5059	s
	.5224	s
	.5514	s
Uranium	.5478	s
	.5480	s
	.5482	s
	.5494	s
	.5528	s
Zinc	.3345	a, s
	.4680	a, s
	.4722	a, s
	.4811	a, s
	.4912	s
	.4925	s
	.6103	s
	.6362	a, s
Zirconium	.3958	a, s
	.3982	a
	.3991	a, s
	.3999	s
	.4049	a, s
	.4073	a
	.4081	a
	.4149	a, s
	.4156	a, s
	.4161	a, s
	.4360	a, s
	.4371	a, s
	.4380	a, s
	.4443	s
	.4494	s
	.4497	a, s
	.4688	s
	.4710	s
	.4739	s
	.4772	s
	.4816	s
	.6128	s
	.6142	s

WAVE LENGTH OF PRINCIPAL LINES OF VARIOUS ELEMENTS (Continued)

Gases

Air (spark) line due to	N .3995	Bromine	.4785
	N .4447		.5332
	N .4631		.6150
	O .4642		.6351
	N .4643	Chlorine, Plücker tube	.3851
	.5001		.3861
	N .5005		.4133
	N .5679		.4253
Argon, Plücker tube (blue spectrum)	.3491		.4344
	.3560		.4794
	.3589		.4810
	.3638		.4819
	.3729		.5423
	.3850	Helium	.3188
	.4072		.3888
	.4104		.4026
	.4228		.4471
	.4331		.5016
	.4348		.5876
	.4426		.6678
	.4430	Hydrogen	.4102
	.4806		.4341
(red spectrum)	.4158		.4861
	.4191		.6563
	.4198	Nitrogen	See air
	.4200	Oxygen	See air
	.4259		
	.4511		
	.6965		
	.7067		

RELATIVE STIMULATION OF THE THREE PRIMARY COLOR SENSATIONS BY DIFFERENT WAVE LENGTHS

Wave length	0.36μ	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54
Red	0.0	0.0	2.0	1.0	1.0	1.0	3.0	9.0	23.0	39.0
Green	0.0	0.0	0.0	0.0	0.0	2.0	7.0	23.0	61.0	87.0
Blue	0.0	10.5	29.0	52.0	76.0	78.0	68.0	46.0	16.0	7.0

Wave length	0.56μ	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74
Red	56.0	69.0	71.5	59.0	30.0	12.0	5.0	2.0	1.0	0.0
Green	86 0	67.0	37.0	10.0	2.5	1.0	0.0	0.0	0.0	0.0
Blue	4.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INDEX OF REFRACTION OF OPTICALLY ISOTROPIC SOLIDS

(From Smithsonian Tables.)

Substance.	Line of spectrum.	Index of refraction.	Observer.
Agate (light color) . .	red	1.537	De Senarmont
Ammonium chloride	*D*	1.642	Grailich
Arsenite.	*D*	1.755	DesCloiseaux
Barium nitrate.	*D*	1.572	Fock
Bell metal.	*D*	1.005	Beer
Blende.	*Li*	2.342	Ramsay
Blende.	*Na*	2.369	Ramsay
Blende.	*Tl*	2.401	Ramsay
Boric acid	*C*	1.462	Bedson & C. Williams
Boric acid	*D*	1.463	Bedson & C. Williams
Boric acid	*F*	1.470	Bedson & C. Williams
Borax (vitrified). . . .	*C*	1.512	Bedson & C. Williams
Borax (vitrified). . . .	*D*	1.515	Bedson & C. Williams
Borax (vitrified). . . .	*F*	1.521	Bedson & C. Williams
Camphor.	*D*	1.532	Kohlrausch
Camphor.	*D*	1.546	Mülheims
Diamond (colorless).	red	2.414	DesCloiseaux
Diamond (colorless).	green	2.428	DesCloiseaux
Diamond (brown) . .	*B*	2.461	Schrauf
Diamond (brown) . .	*D*	2.470	Schrauf
Diamond (brown) . .	*E*	2.479	Schrauf
Ebonite.	*D*	1.6	Ayrton & Perry
Fuchsin.	*A*	2.03	Means
Fuchsin.	*B*	2.19	Means
Fuchsin.	*C*	2.33	Means
Fuchsin.	*G*	1.97	Means
Fuchsin.	*H*	1.32	Means
Garnet (different varieties).	*D*	1.74–1.90	Various
Gum arabic.	red	1.480	Jamin
Gum arabic.	red	1.514	Wollaston
Hanyne.	*D*	1.496	Tschichatscheff
Helvine.	*D*	1.739	Levy & Lecroix
Obsidian.	*D*	1.482–1.496	Various
Opal.	*D*	1.406	Various
Opal.	*D*	1.450	Various
Pitch	red	1.531	Wollaston
Potassium bromide .	*D*	1.559	Topsöe and Christiansen
chlorstannate. . . .	*D*	1.657	Topsöe and Christiansen
iodide.	*D*	1.667	Topsöe and Christiansen
Phosphorus.	*D*	2.144	Gladstone & Dale

INDEX OF REFRACTION OF OPTICALLY ISOTROPIC SOLIDS (Continued)

Substance.	Line of spectrum.	Index of refraction.	Observer.
Resins: aloes	red	1.619	Jamin
Canada balsam	red	1.528	Wollaston
colophony	red	1.548	Jamin
copal	red	1.528	Jamin
mastic	red	1.535	Wollaston
Peru balsam	*D*	1.593	Baden Powell
Selenium, vitreous	*A*	2.612	Wood
Selenium, vitreous	*B*	2.680	Wood
Selenium, vitreous	*C*	2.729	Wood
Selenium, vitreous	*D*	2.93	Wood
Silver bromide	*D*	2.253	Wernicke
chloride	*D*	2.061	Wernicke
iodide	*D*	2.182	Wernicke
Sodalite, blue	*D*	1.483	Feusner
Sodalite, clear like water	*D*	1.483	Feusner
Sodium chlorate	*D*	1.515	Dussaud
Spinel	*D*	1.716	DesCloiseaux
Strontium nitrate	*D*	1.567	Fock

INDEX OF REFRACTION OF UNIAXIAL CRYSTALS

Substance.		Index of refraction.			
		Line of spectrum.	Ordinary ray.	Extraordinary ray.	Observer.
Alunite (alum stone)		*D*	1.573	1.592	Levy & Lacroix
Apatite		*D*	1.639	1.635	Schrauf
Beryl	from	*D*	1.589	1.582	Various
	to	*D*	1.570	1.566	Various
Calomel		red	1.96	2.60	De Senarmont
Cinnabar		red	2.854	3.199	DesCloiseaux
Corundum (ruby, sapphire, etc.)	from	red	1.767	1.759	DesCloiseaux
	to	red	1.769	1.762	DesCloiseaux
Emerald (pure)		green	1.584	1.578	DesCloiseaux
Ice at −8° C.		*D*	1.309	1.313	Meyer
Ivory		*D*	1.539	1.541	Kohlrausch
Sodium nitrate		*D*	1.587	1.336	Schrauf
Tourmaline (colorless)		*D*	1.637	1.619	Heusser
Tourmaline (different colors)	from	*D*	1.633	1.616	Jeroféjew
	to	*D*	1.650	1.625	Jeroféjew

INDEX OF REFRACTION OF BIAXIAL CRYSTALS

Substances.	Index of refraction.				
	Line of spectrum.	Minimum.	Intermediate.	Maximum.	Observer.
Borax	*D*	1.447	1.469	1.472	Dufet
Copper sulphate	*D*	1.514	1.537	1.543	Kohlrausch
Gypsum	*D*	1.521	1.523	1.530	Mülheims
Mica (muscovite)	*D*	1.560	1.594	1.598	Pulfrich
Potassium bichromate	*D*	1.720	1.738	1.820	Dufet
nitrate	*D*	1.335	1.506	1.506	Schrauf
sulphate	*D*	1.493	1.495	1.498	Topsöe & Christiansen
Sugar (cane)	*D*	1.540	1.567	1.572	Calderon
Sulphur (rhombic)	*D*	1.951	2.038	2.241	Schrauf
Topaz (Brazilian)	*D*	1.629	1.631	1.638	Mülheims

INDEX OF REFRACTION OF GLASS

RELATIVE TO AIR

Variety.	Wave length in microns.							
	.361	.434	.486	.589 (Na)	.656	.768	1.20	2.00
Zinc crown	1.539	1.528	1.523	1.517	1.514	1.511	1.505	1.497
Higher dispersion crown	1.546	1.533	1.527	1.520	1.517	1.514	1.507	1.497
Light flint	1.614	1.594	1.585	1.575	1.571	1.567	1.559	1.549
Heavy flint	1.705	1.675	1.664	1.650	1.644	1.638	1.628	1.617
Heaviest flint	...	1.945	1.919	1.890	1.879	1.867	1.848	1.832

INDEX OF REFRACTION OF ROCK SALT, SILVINE, CALCITE, FLUORITE AND QUARTZ

(Compiled from data of Martens, Paschen, and others.)

Wave length.	Rock salt.	Silvine, KCl.	Fluorite.	Calcspar, ordinary ray.	Calcspar, extraordinary ray.	Quartz, ordinary ray.	Quartz, extraordinary ray.
0.185	1.893	1.827	......	......	......	1.676	1.690
0.198	.....	......	1.496	......	1.578	1.651	1.664
0.340	.....	......	......	1.701	1.506	1.567	1.577
0.589	1.544	1.490	1.434	1.658	1.486	1.544	1.553
0.760	.....	......	1.431	1.650	1.483	1.539	1.548
0.884	1.534	1.481	1.430				
1.179	1.530	1.478	1.428				
1.229	.....	......	......	1.639	1.479		
2.324	.....	......	......	......	1.474	1.516	
2.357	1.526	1.475	1.421				
3.536	1.523	1.473	1.414				
5.893	1.516	1.469	1.387				
8.840	1.502	1.461	1.331				

INDEX OF REFRACTION, LIQUIDS

(From Smithsonian Tables.)

Substance.	Temp. °C.	Index of refraction for spectrum lines. C	D	F	H	Observer.
Acetone	10.	1.363	1.365	1.369	...	Korten
Almond oil	0	1.476	1.478	1.485	...	Olds
Anilin	20.	1.599	1.586	1.604	...	Weegman
Aniseed oil	21.4	1.541	1.548	1.565	...	Willigen
Aniseed oil	15.1	1.551	1.557	1.574	1.608	Baden Powell
Benzene	10	1.498	1.503	1.515	1.536	Gladstone
Benzene	21.5	1.493	1.498	1.510	1.530	Gladstone
Bitter almond oil	20	1.539	...	1.562	...	Landolt
Bromnaphthalin	20	1.650	1.658	1.682	1.729	Walter
Carbon disulphide	0	1.634	1.643	1.669	1.718	Ketteler
Carbon disulphide	20	1.618	1.628	1.652	1.699	Ketteler
Carbon disulphide	10	1.625	1.634	1.659	1.708	Gladstone
Carbon disulphide	19	1.619	1.628	1.635	1.701	Dufet
Cassia oil	10	1.601	1.610	1.639	1.704	Baden Powell
Cassia oil	22.5	1.593	1.603	1.631	1.699	Baden Powell
Cedar oil	22	...	1.515	...	...	Texier
Chinolin	20	1.609	1.617	1.636	...	Gladstone
Chloroform	10	1.447	1.449	1.456	1.461	Gladstone & Dale
Chloroform	30	...	1.440	...	1.456	Gladstone & Dale
Chloroform	20	1.444	1.446	1.453	...	Lorenz
Cinnamon oil	23.5	1.608	1.619	1.651	...	Willigen
Ether	15	1.355	1.357	1.361	1.368	Gladstone & Dale
Ether	15	1.357	1.359	1.364	1.371	Kundt
Ethyl alcohol	0	1.368	1.369	1.374	...	Korten
Ethyl alcohol	10	1.364	1.365	1.370	...	Korten
Ethyl alcohol	20	1.360	1.361	1.366	...	Korten
Ethyl alcohol	15	1.362	1.364	1.368	1.375	Gladstone & Dale
Glycerine	20	1.471	...	1.478	...	Landolt
Methyl alcohol	15	1.331	1.333	1.336	1.342	Baden Powell
Olive oil	0	1.474	1.476	1.483	...	Olds
Rock oil	0	1.435	1.457	1.464	...	Olds
Turpentine oil	10.6	1.472	1.474	1.481	1.494	Frauenhofer
Turpentine oil	20.7	1.469	1.472	1.479	1.491	Willigen
Toluene	20	1.491	1.496	1.507	...	Bruhl
Water	20	1.331	1.333	1.337	1.344	Means

DISPERSION

The dispersion for various types of optical glass is shown in the following table. n_D = index of refraction for the *D* line (of the solar spectrum) and n_F and n_C the index for the *F* and *C* lines respectively $(n_F - n_D)$ shows the dispersion for these two wave lengths.

Glass.	n_D	$(n_F - n_C)$
Light phosphate crown	1.5159	.00737
Barium-silicate crown	1.5399	.00909
High-dispersion crown	1.5262	.01026
Borate flint	1.5686	.01102
Extra light flint	1.5398	.01142
Heavy flint	1.7174	.02434
Heaviest flint	1.9626	.04882

INDEX OF REFRACTION, AQUEOUS SOLUTIONS

Substance.	Density.	Temp. °C.	Index for λ = .5893 (Na)	Observer.
Ammonium chloride .	1.067	27.05	1.379	Willigen
Ammonium chloride.	1.025	29.75	1.351	Willigen
Calcium chloride. . . .	1.398	25.65	1.443	Willigen
Calcium chloride. . . .	1.215	22.9	1.397	Willigen
Calcium chloride. . . .	1.143	25.8	1.374	Willigen
Hydrochloric acid. . .	1.166	20.75	1.411	Willigen
Nitric acid.	1.359	18.75	1.402	Willigen
Potash (caustic).	1.416	11.0	1.403	Frauenhofer
Potassium chloride. . .	Normal	solution	1.343	Bender
Potassium chloride. . .	Double	normal	1.352	Bender
Potassium chloride. . .	Triple	normal	1.360	Bender
Soda (caustic).	1.376	21.6	1.413	Willigen
Sodium chloride.	1.189	18.07	1.378	Schutt
Sodium chloride.	1.109	18.07	1.360	Schutt
Sodium chloride.	1.035	18.07	1.342	Schutt
Sodium nitrate.	1.358	22.8	1.385	Willigen
Sulphuric acid.	1.811	18.3	1.437	Willigen
Sulphuric acid.	1.632	18.3	1.425	Willigen
Sulphuric acid.	1.221	18.3	1.370	Willigen
Sulphuric acid.	1.028	18.3	1.339	Willigen
Zinc chloride.	1.359	26.6	1.402	Willigen
Zinc chloride.	1.209	26.4	1.375	Willigen

INDEX OF REFRACTION OF METALS

For Sodium Light

(Drude.)

Metal.	Index of refraction.	Metal.	Index of refraction.
Aluminum.	1.44	Mercury.	1.73
Antimony.	3.04	Nickel.	1.79
Bismuth.	1.90	Platinum.	2.06
Cadmium.	1.13	Silver.	0.181
Copper.	0.641	Steel.	2.41
Gold.	0.366	Tin, solid.	1.48
Iron.	2.36	Tin, fluid.	2.10
Lead.	2.01	Zinc.	2.12
Magnesium.	0.37		

DIFFUSED REFLECTION (ALBEDO)

Ratio of total quantity of light reflected by a surface to the total incident light.

White pinewood.	0.40	Blotting paper, white.	0.70–.80
Paper, ordinary white	.60–.70	blue.	.25
Black velvet.	.004	yellow.	.40
Snow.	.78	Earth, moist.	.08

INDEX OF REFRACTION, GASES

Values are relative to a vacuum and for a temp. of 0° C. and 760 mm. pressure.

(From Smithsonian Tables.)

Substance.	Kind of light.	Indices of refraction.	Observer.
Acetone	*D*	1.001079–1.001100	
Air	*D*	1.0002926	Perreau
Ammonia	white	1.000381–1.000385	
Ammonia	*D*	1.000373–1.000379	
Argon	*D*	1.000281	Rayleigh
Benzene	*D*	1.001700–1.001823	
Bromine	*D*	1.001132	Mascart
Carbon dioxide	white	1.000449–1.000450	
dioxide	*D*	1.000448–1.000454	
disulphide	white	1.001500	Dulong
disulphide	*D*	1.001478–1.001485	
monoxide	white	1.000340	Dulong
monoxide	white	1.000335	Mascart
Chlorine	white	1.000772	Dulong
Chlorine	*D*	1.000773	Mascart
Chloroform	*D*	1.001436–1.001464	
Cyanogen	white	1.000834	Dulong
Cyanogen	*D*	1.000784–1.000825	
Ethyl alcohol	*D*	1.000871–1.000885	
ether	*D*	1.001521–1.001544	
Helium	*D*	1.000036	Ramsay
Hydrochloric acid	white	1.000449	Mascart
Hydrochloric acid	*D*	1.000447	Mascart
Hydrogen	white	1.000138–1.000143	
Hydrogen	*D*	1.000132	Burton
sulphide	*D*	1.000644	Dulong
sulphide	*D*	1.000623	Mascart
Methane	white	1.000443	Dulong
Methane	*D*	1.000444	Mascart
Methyl alcohol	*D*	1.000549–1.000623	
Methyl ether	*D*	1.000891	Mascart
Nitric oxide	white	1.000303	Dulong
Nitric oxide	*D*	1.000297	Mascart
Nitrogen	white	1.000295–1.000300	
Nitrogen	*D*	1.000296–1.000298	
Nitrous oxide	white	1.000503–1.000507	
Nitrous oxide	*D*	1.000516	Mascart
Oxygen	white	1.000272–1.000280	
Oxygen	*D*	1.000271–1.000272	
Pentane	*D*	1.001711	Mascart
Sulphur dioxide	white	1.000665	Dulong
Sulphur dioxide	*D*	1.000686	Ketteler
Water	white	1.000261	Jamin
Water	*D*	1.000249–1.000259	

COEFFICIENT OF TRANSPARENCY OF UVIOL GLASS FOR THE ULTRA-VIOLET

For a thickness of 1 mm.

Wave length, microns	0.280	0.309	0.325	0.346	0.361	0.383	0.397
Uviol crown	0.56	0.95	0.990	0.996	0.999	1.000	1.000

REFLECTION OF LIGHT BY GLASS IN AIR

The table gives the per cent of the incident light which is reflected from the surface of glass in air assuming an index of refraction of 1.55; *i* represents the angle of incidence and *R* the per cent of light reflected.

(Computed according to Fresnel's formula, see page 223.)

i	*R*	*i*	*R*	*i*	*R*
0°	4.65				
5	4.65	35°	4.98	65°	12.91
10	4.66	40	5.26	70	18.00
15	4.66	45	5.73	75	26.19
20	4.68	50	6.50	80	39.54
25	4.73	55	7.74	85	61.77
30	4.82	60	9.73	90	100.

REFLECTION BY TRANSPARENT MEDIA IN AIR

For Normal Incidence

The table gives the per cent of the normally incident light which is reflected by transparent media of various indices of refraction. n = index of refraction, R = reflected light, i = angle of incidence = 0.

(Computed from Fresnel's formula.)

n	*R*	*n*	*R*	*n*	*R*
1.0	0.00	1.7	6.72	2.4	17.0
1.1	0.23	1.8	8.16	2.5	18.4
1.2	0.83	1.9	9.63	2.6	19.8
1.3	1.70	2.0	11.11	2.7	21.1
1.4	2.78	2.1	12.6	2.8	22.5
1.5	4.00	2.2	14.1	2.9	23.8
1.6	5.33	2.3	15.5	3.0	25.0

COEFFICIENT OF TRANSPARENCY OF GLASS FOR THE INFRA-RED

Normal incidence, thickness 1 cm.

Wave length, microns....	0.7	1.1	1.7	2.3	2.7	3.1
Crown, borate..........	1.00	.55	.21	.025	.04	
borosilicate...........	...	.74	.61	.33	.034	.021
Flint, light.............	1.00	.91	.82	.45	.083	.019
heavy...............	1.00	1.00	1.00	1.00	.45	.019

REFLECTION OF LIGHT BY METALS

The table gives the per cent of normally incident light which is reflected by the polished surface of various metals.

Wave length.	Anti-mony.	Bronze (68Cu, 68Sn).	Copper, commer-cial.	Gold, electro-lytic.	Iron.	Magna-lium, Mach's.	Mag-ne-sium.	Mer-cury, backed glass.
.251	....	.30	25.9	38.8	....	67.0		
.288	....	....	24.3	34.0	....	70.6		
.305	....	....	25.3	31.8	....	72.2		
.326	....	....	24.9	28.6	....	75.5		
.357	....	....	27.3	27.9	....	81.2		
.385	....	.53	28.6	27.1	....	83.9		
.420	....	....	32.7	29.3	....	83.3		
.450	....	....	37.0	33.1	....	83.4	....	72.8
.500	....	.63	43.7	47.0	.55	83.3	.72	70.9
.550	....	....	47.7	74.0	....	82.7	....	71.2
.600	.53	.64	71.8	84.4	.57	83.0	.73	69.9
.650	....	....	80.0	88.9	....	82.7	....	71.5
.700	....	....	83.1	92.3	.59	83.3	....	72.8
.800	....	....	88.6	94.9	....	84.3		
1.00	.55	.70	90.1	......	.65	84.1	.74	
2.0	.60	.80	95.5	96.8	.78	86.7	.77	
3.0	.65	.86	97.1	......	.84	87.4	.80	
4.0	.68	.88	97.3	96.9	.89	88.7	.83	
9.0	.72	.93	98.4	98.0	.94	90.6	.93	

Wave length.	Nickel, electro-lytic.	Plati-num, electro-lytic.	Silver, chemi-cally depos-ited.	Silver-backed glass.	Specu-lum metal.	Steel.	Tung-sten.
.251	37.8	33.8	34.1	......	29.9	32.9	
.288	42.7	38.8	21.2	......	37.7	35.0	
.305	44.2	39.8	9.1	......	41.7	37.2	
.326	45.2	41.4	14.6	......	......	40.3	
.357	48.8	43.4	74.5	......	51.0	45.0	
.385	49.6	45.4	81.4	......	53.1	47.8	
.420	56.6	51.8	86.6	......	56.4	51.9	
.450	59.4	54.7	90.5	85.7	60.0	54.4	
.500	60.8	58.4	91.3	86.6	63.2	54.8	.49
.550	62.6	61.1	92.7	88.2	64.0	54.9	
.600	64.9	64.2	92.6	88.1	64.3	55.4	.51
.650	66.6	66.5	94.7	89.1	65.4	56.4	
.700	68.8	69.0	95.4	89.6	66.8	57.6	.54
.800	69.6	70.3	96.8	......	......	58.0	
1.00	72.0	72.9	97.0	......	70.5	63.1	.62
2.0	83.5	80.6	97.8	......	80.4	76.7	.85
3.0	88.7	88.8	98.1	......	86.2	83.0	.90
4.0	91.1	91.5	98.5	......	88.5	87.8	.93
9.0	95.6	95.4	98.7	......	92.2	92.9	.95

TRANSMISSIBILITY FOR RADIATIONS

Ratio of the transmitted light to the incident light for a definite thickness of the substance, usually 1 cm.

Glass.

Glass in general is opaque to the ultra-violet and infra-red. Uviol glass is transparent to the longer radiations of the ultra-violet.

Coefficient of transparency of glass for visible and ultra-violet radiations.

	Normal incidence, thickness 1 cm.								
Wave-length microns	0.309	0.330	0.347	0.357	0.361	0.375	0.384	0.388	0.396
Crown, ordinary	...	...	...	...	...	.947			
Crown, borosilicate	0.08	0.65	0.88	...	0.95	...	0.972	0.975	0.986
Flint, ordinary	...	...	...	0.72	...	...	...	0.904	
Flint, heavy	...	...	0.01	...	0.16	...	0.58		

	Normal incidence, thickness 1 cm.								
Wave length, microns	0.400	0.415	0.419	0.425	0.434	0.455	0.500	0.580	0.677
Crown, ordinary	0.964	...	0.952	...	0.960	0.981	...	0.986	0.990
Crown, borosilicate	...	0.985	...	0.993	...	...	0.993		
Flint, ordinary	...	0.959	...	...	...	...	1.00		
Flint, heavy	...	...	...	0.905					

See also pp. 175 and 176.

Quartz

Quartz is very transparent to the ultra-violet and to the visible spectrum, but opaque for the infra-red beyond 7.0μ.

(Pflüger.)

Wave length, microns	0.19	0.20	0.21	0.22
Transmission for 1 mm	.67	.84	.92	.94

Fluorite

Fluorite is very transparent to the ultra-violet, nearly to 0.10μ. Coefficient of transparency at $\lambda = 186$ is found by Pflüger to be 0.80.

For the infra-red the values are given in a table below.

TRANSMISSIBILITY FOR RADIATIONS (Continued)

Rock Salt and Sylvine and Fluorite

Transparency for the Infra-red.

Thickness 1 cm.

Wave length, microns.	Rock salt.	Sylvine KCl.	Fluorite.
8.	....	....	.844
9.	0.995	1.000	.543
10.	.995	.988	.164
12.	.993	.995	.010
14.	.931	.975	.000
16.	.661	.936	
18.	.275	.862	
19.	.096	.758	
20.7	.006	.585	
23.7	.000	.155	

PHOSPHORESENCE BY CATHODE RAYS

Substances Luminous under Excitation by Cathode Rays.

Substance (with calcium oxide).	Wave lengths of principal bands in microns. (Urbain, 1909.)
Dysprosium oxide........	0.480, 0.489, 0.585, 0.675
Europium oxide.........	0.416–0.426, 0.469
Europium oxide..........	0.589–0.593, 0.613, 0.625
Neodymium oxide........	0.392, 0.419–0.429, 0.458
Praesodymium oxide.....	0.488, 0.604, 0.606, 0.626, 0.634

One part.	100 parts.	Wave length.	Color.	Observer.
Antimony oxide..	calcium oxide	0.560	yellow	Bruninghaus, 1910
Antimony trisulphide.........	calcium sulphide	0.569	yellow	Bruninghaus, 1910
Bismuth oxide...	calcium oxide	0.522	blue	Bruninghaus, 1910
Bismuth sulphate.	calcium sulphate	0.640	red	Bruninghaus, 1910
Manganous carbonate........	magnesium carbonate	0.620	red	Bruninghaus, 1910
oxide.........	calcium oxide	0.589	yellow	Lecoq & Boisbaudran, 1886
phosphate.....	calcium phosphate $Ca_3(PO_4)_2$	0.633	red	Bruninghaus, 1910
sulphate.......	calcium sulphate	0.540	green	Lecoq & Boisbaudran, 1886
sulphide.......	calcium sulphide	0.589	yellow	Bruninghaus, 1910

FLUORESCENCE OF ORGANIC SUBSTANCES IN SOLUTION

Excitation by White Light.

Substance.	Solvent.	Wave length microns.	Observer.
Anthracene	alcohol	0.400 0.430 0.436	Stark & Meyer, 1907
Eosine	alcohol or water	0.589	Nichols & Merritt, 1907
Esculine	alcohol	0.460	Nichols & Merritt, 1907
Fluorescein	water (alkaline)	0.542	Nichols & Merritt, 1907
Naphthalin, red	alcohol	0.632	Nichols & Merritt, 1907
Quinine sulphate	water	0.437	Nichols & Merritt, 1907
Resorcin blue	water	0.65	Nichols & Merritt, 1907
Rhodamin	water	0.554	Nichols & Merritt, 1907

FLUORESCENCE

Gases and Vapors.

Gas or vapor.	Condition.	Excitation.	Color or wave length of emitted light.	Observer.
Iodine	Vapor at ordinary temperature.	Mercury arc $\lambda = .546\mu$	Strongest bands $\lambda = .5460\mu, .5774\mu$ .5730, .5796	Wood, 1911
Mercury	Vapor at ordinary temperature	Spark between aluminum electrodes	Broad band $\lambda = .5900-.3000$	Wood, 1909
Oxygen	....	Mercury arc in quartz tube	Strongest lines $\lambda = .1849, .1851$ (ultra-violet)	Streubing, 1910
Potassium	Vapor, 300°–400° C.	White light	Many strong lines from .6416–.6768, strongest .6544 and .6584	Wood & Carter, 1908
Rubidium	Vapor, at 270° C.	White light (elec. arc)	Strong red band $\lambda = .6900-.6620$.	Dunoyer, 1912
Sodium	Vapor at 350° C.	White light (elec. arc)	D, $\lambda = .5893$ (mean)	Dunoyer, 1912

SPECIFIC ROTATION

The tables give the specific rotation in degrees for one decimeter; + signifies right-handed rotation, − left. Rotation is for sodium light.

LIQUIDS

Liquid.	Temp. ° C.	Specific Rotation. Degrees.	Observer.
Amyl alcohol.....	....	−5.7	Le Bel
Camphor.........	204	+70.33	Gernez
Cedar oil.........	15	−30 to −40	
Citron oil.........	15	+62	
Menthol..........	35.2	−49.7	Paterson & Taylor
Nicotine..........	22.7	+150.0	Molby
Oil of turpentine...	15	−20 to −40	

SOLUTIONS

Giving the rotation for one decimeter, for one gram of active substance in one cubic centimeter of solution.

Active substance.	Solvent.	Temp. ° C.	Spec. rot.	Observer.
Albumen, egg...	water	....	−25 to −38	
Camphor.......	ether	....	+57.	Darmois, 1910
Dextrose (β)....	water	15	+52.5	Tanret, 1896
Glucose (β).....	water	20	+51.4	
Lactose........	water	15	56.	
Maltose........	water	20	+136.9	
Quinine sulphate	alcohol	17	−57.5	Oudemans, 1876
Sugar cane.....	water	20	66.5	
Tartaric acid....	water	20	+13.44	Wendel, 1898

SOLIDS

(Rotation per millimeter.)

Substance.	Rotation.	Substance.	Rotation.
Cinnabar (HgS)....	32.5	Quartz...........	21.7
Lead hyposulphate.	5.5	Sodium bromate...	2.8
Potassium " .	8.4	Sodium chlorate...	3.13

MAGNETO OPTIC ROTATION

$$\text{Verdet's Constant: } \rho = \frac{\alpha}{tH \cos \theta}$$

The specific power of magnetic rotation ρ, is expressed in the above formula, where α is the total angle of rotation in minutes, t the thickness of the substance in centimeters, H the magnetic field intensity in gausses and θ the angle between the direction of the magnetic field and the path of light.

Solids

For sodium light.
(Values from the Smithsonian Tables.)

Substance.	Temp. ° C.	Verdet's Constant, Minutes.	Observer.
Amber	18–20	0.0095	Quincke
Blende	15	0.2234	Becquerel
Diamond	15	0.0127	Becquerel
Fluorspar	15	0.0087	Becquerel
Glass, crown	15	0.0203	Becquerel
flint	18–20	0.0420	Quincke
flint, dense	15	0.0647	Becquerel
Quartz (⊥ to axis)	18–20	0.0172	Quincke
Rock salt	15	0.0355	Becquerel
Selenium	15	0.4625	Becquerel
Sylvine	15	0.0283	Becquerel

Liquids

For sodium light.

Substance.	Density g/cm.³	Temp. ° C.	Verdet's Constant, minutes.	Observer.
Acetone	0.7947	20	0.0113	Jahn
Acids: (see also solutions in water) acetic	1.0561	21	0.0105	Perkin
hydrochloric	1.2072	15	0.0224	Perkin
hydrobromic	1.7859	15	0.0343	Perkin
nitric	1.5190	13	0.0070	Perkin
sulphuric	......	15	0.0121	Becquerel
sulphurous	......	15	0.0153	Becquerel
Alcohols: amyl	......	15	0.0131	Becquerel
ethyl	0.7929	18–20	0.0107	Quincke
methyl	0.7915	18–20	0.0094	Quincke
Benzine	0.8796	20	0.0297	Jahn
Carbon disulphide	1.2644	18–20	0.0441	Quincke
Chloroform	1.4	20	0.0164	Jahn
Phosphorus (melted)	....	33	0.1316	Becquerel
Sulphur (melted)	....	114	0.0803	Becquerel
Toluene	....	28.4	0.0269	Becquerel
Water	....	18–20	0.0130	Schönrock
Xylene	....	15	0.0221	Becquerel
Zinc bichloride	....	15	0.0437	Becquerel

MAGNETO OPTIC ROTATION (Continued)

Aqueous Solutions

For sodium light.

Salt.	Density, g/cm³.	Temp. °C.	Verdet's constant, minutes.	Observer.
Acids: hydrochloric	1.1856	15	0.0219	Perkin
hydrochloric	1.1279	15	0.0193	Perkin
hydrochloric	1.0323	20	0.0150	Jahn
nitric	1.3560	20	0.0105	Perkin
Ammonia	0.8918	15	0.0153	Perkin
Bromides: barium	1.5399	20	0.0215	Jahn
potassium	1.1424	20	0.0163	Jahn
sodium	1.1351	20	0.0165	Jahn
Carbonate of potassium	1.1960	20	0.0140	Jahn
Carbonate of sodium	1.1006	20	0.0140	Jahn
Chlorides: barium	1.2897	20	0.0168	Jahn
cadmium	1.3179	20	0.0185	Jahn
calcium	1.1504	20	0.0165	Jahn
iron (ferrous)	1.4331	15	0.0025	Becquerel
iron (ferric)	1.6933	15	−0.2026	Becquerel
lithium	1.0619	20	0.0145	Jahn
mercury	1.0381	16	0.0137	Schönrock
potassium	1.6000	15	0.0163	Becquerel
sodium	1.2051	15	0.0180	Becquerel
zinc	1.2851	15	0.0196	Verdet
Bichromate of potassium	1.0786	15	0.0126	Verdet
Iodides: potassium	1.6743	15	0.0338	Becquerel
Sulphates: barium	1.1788	20	0.0134	Jahn
potassium	1.0475	20	0.0133	Jahn
sodium	1.0661	20	0.0135	Jahn

Gases

For sodium light.

Substance.	Pressure.	Temp. °C	Verdet's constant, minutes.	Observer.
Atmospheric air	atmos.	ordinary	6.83×10^{-6}	Becquerel
Carbon dioxide	atmos.	ordinary	13.00	Becquerel
Carbon disulphide	74 cms.	70°	23.49	Bichat
Ethylene	atmos.	ordinary	34.48	Becquerel
Nitrogen	atmos.	ordinary	6.92	Becquerel
Nitrous oxide	atmos.	ordinary	16.90	Becquerel
Oxygen	atmos.	ordinary	6.28	Becquerel
Sulphur dioxide	atmos.	ordinary	31.39	Becquerel
Sulphur dioxide	246 cms	20°	38.40	Bichat

MISCELLANEOUS TABLES

α RAYS

The α rays are thought to be positively charged particles, moving with a high velocity. They are only slightly deviable by a strong magnetic or electric field and have small penetrating power. The initial velocity has been found to be about 2×10^9 cms./s. The mass of each particle is 6.2×10^{-24} g. (Rutherford and Geiger, 1910.) The charge carried by each, as measured by the same authors, is 9.3×10^{-10} electro static units.

β RAYS

The β rays are similar to the cathode rays produced by an electric discharge in a vacuum tube. They are judged to be negatively charged particles moving with high velocity. They are much more penetrating than the α rays, and are strongly deviated by a magnetic or electric field. The velocity of the moving particle is in the neighborhood of that of light, about 2×10^{10} cm./s. The charge on each particle is approximately 4.7×10^{-10} electro static units.

γ RAYS

The γ rays are similar to the X rays and are not deviable by magnetic or electric fields. They are more penetrating than either the α or β rays, and are considered to be of the nature of wave pulses in the ether.

RÖNTGEN RAYS

Scale of Hardness

The "radiochrometer" of Benoist consists of a disk of silver 0.11 mm. thick, which is surrounded by 12 sectors of aluminum ranging in thickness from 1 to 12 millimeters. The sector which shows the same absorption as the central disk gives the degree of hardness according to Benoist. The relation of this to other scales is shown below.

Benoist	2	3	4	5	6	7	8
Wehnelt	1.8–2	5	6.5	7.5	8	9	10–11
Walter	2.0–3	4–5	5–6	6	6–7	7	7–8

The absorption of rays is very nearly proportional to the mass of substance penetrated.

RADIOACTIVE SUBSTANCES

A list of the fully recognized radioactive substances and transformation products. In each series, each product is obtained from the substance preceding. The table gives also (1) the rays emitted, (2) the transformation period, that is, the time taken for half the active product to undergo change and (3) the radioactive constant, λ, the proportion of active matter which undergoes change each second.

Substance.	Properties, etc.	Rays.	Transformation period.	Radioactive constant.
Uranium I	Atomic weight, 238.5	α	5×10^9 yrs.	
Uranium II		α	2×10^6 yrs. (?)	
Uranium X	Chemically separated from uranium	β, γ	18 days	3.3×10^{-7}
Ionium		α	2.5×10^5 yrs. (?)	
Radium	Metal similar to barium, from which it is separated by fractional crystallization of the bromide or chloride. Atomic weight 226.5	α, β	1750 yrs.	1.3×10^{-11}
Emanation from radium	Inert gas of high molecular weight given off by radium salts	α	3.8 days	2.1×10^{-6}
Radium A	Deposited on the surface of bodies exposed to the emanation, concentrated on the cathode in an electric field. Volatile at about 800 to 900° C	α	3 minutes	3.85×10^{-3}
Radium B	Origin as of radium A, volatile at 600 to 700° C	β, γ	19 minutes	4.33×10^{-4}
Radium C	Origin as of radium A, volatile at a higher temperature than radium B	α, β, γ	14 minutes	5.9×10^{-4}
Radium C_2		β	1 minute	
Radium D	Soluble in acids, volatile below 1000° C	β	16.5 yrs.	1.3×10^{-9}
Radium E	Non-volatile at 1000° C	β	4 days	1.6×10^{-6}
Radium F	Deposited on silver or bismuth from an acid solution. Indentical with polonium	α	136 days	5.7×10^{-8}

RADIOACTIVE SUBSTANCES (Continued)

A list of the fully recognized radioactive substances and transformation products. In each series, each product is obtained from the substance preceding. The table gives also (1) the rays emitted, (2) the transformation period, that is, the time taken for half the active product to undergo change, and (3) the radioactive constant, λ, the proportion of active matter which undergoes change each second.

Substance.	Properties, etc.	Rays.	Transformation period.	Radioactive Constant.
Actinum		No rays		
Radioactinum		α, β	19.5 days	4.0×10^{-7}
Actinum X		α	10 days	7.6×10^{-7}
Emanation of actinum	Gas of properties similar to those of radium emanation	α	3.9 seconds	.17
Actinum A	Analogous with the corresponding members of the radium group	α	0.002 second	350.
Actinum B		β	36 minutes	3.0×10^{-4}
Actinum C		α	1 minute	5.4×10^{-3}
Actinum D		β, γ	4.7 minutes	2.3×10^{-3}
Thorium	Atomic weight, 232	α	2×10^{10} years	
Meso thorium 1		No rays	4 years	
Meso thorium 2		β, γ	4.5 hours	
Radio thorium		α	2 years	
Thorium X		α, β, (?)	3.6 days	2.2×10^{-6}
Emanation of thorium		α	38 seconds	1.31×10^{-2}
Thorium A	Analogous to corresponding members of the actinum and radium groups	α	.14 second	5
Thorium B		β	11 hours	1.8×10^{-5}
Thorium C_1		α	55 minutes	2.1×10^{-4}
Thorium D		β, γ	3.1 minutes	3.7×10^{-3}
Potassium	Atomic weight, 39.1	β		
Rubidium	Atomic weight, 85.1	β		

Note: The data above are compiled from results by Rutherford, Curie, values given by Debierne and others. The figures can be considered only approximate.

DECLINATION OF THE SUN AND EQUATION OF TIME

Date.		Declination.	Diff. 1 day.	Equation of time.		Date.		Declination.	Diff. 1 day.	Equation of time.	
		°	°	m	s			°	°	m	s
Jan.	0	−23.1	0.11	+ 3	15	July	9	+22.4	0.15	+ 4	49
	10	−22.0	0.18	+ 7	42		19	+20.9	0.21	+ 5	58
	20	−20.2	0.25	+11	13		29	+18.8	0.26	+ 6	13
	30	−17.7	0.30	+13	32	Aug.	8	+16.2	0.30	+ 5	27
Feb.	9	−14.7	0.34	+14	27		18	+13.2	0.34	+ 3	44
	19	−11.3	0.37	+14	5		28	+ 9.8	0.36	+ 1	11
Mar.	1	− 7.6	0.38	+12	36	Sept.	7	+ 6.2	0.39	− 1	59
	11	− 3.8	0.40	+10	15		17	+ 2.3	0.39	− 5	26
	21	+ 0.2	0.39	+ 7	23		27	− 1.5	0.38	− 8	55
	31	+ 4.1	0.38	+ 4	19	Oct.	7	− 5.4	0.38	−12	4
Apr.	10	+ 7.9	0.35	+ 1	23		17	− 9.2	0.35	−14	31
	20	+11.4	0.33	− 1	5		27	−12.7	0.32	−16	0
	30	+14.7	0.29	− 2	52	Nov.	6	−15.9	0.26	−16	16
May	10	+17.6	0.23	− 3	48		16	−18.7	0.22	−15	7
	20	+19.9	0.18	− 3	45		26	−20.9	0.16	−12	36
	30	+21.7	0.12	− 2	49	Dec.	6	−22.5	0.08	− 8	54
June	9	+22.9	0.05	− 1	11		16	−23.3	0.01	− 4	17
	19	+23.4	0.01	+ 0	55		26	−23.4	0.08	+ 0	41
	29	+23.3	0.09	+ 3	2	Jan.	5	−22.6	....	+ 5	34

MEAN PLACES OF STARS

Jan. 0, 1913
(Ephemeris, 1913.)

Name of star.	Right Ascen.			Annual Var.	Declination.			Annual Var.
	h	m	s	s	°	′	″	″
α Andromeda (Alpheratz).	0	3	53.3	+ 3.10	+28	36	36.5	+19.88
α Ursæ Min. (Polaris)....	1	28	19.0	+28.06	+88	50	29.4	+18.58
α Arietis................	2	2	15.9	+ 3.38	+23	3	5.6	+17.12
α Persei.................	3	18	6.3	+ 4.27	+49	33	8.6	+12.98
α Tauri (Aldebaran)......	4	30	55.6	+ 3.44	+16	20	6.7	+ 7.41
α Aurigæ (Capella).......	5	10	15.6	+ 4.43	+45	54	38.2	+ 3.89
β Orionis (Rigel)........	5	10	21.4	+ 2.88	− 8	18	5.0	+ 4.31
ε Orionis................	5	31	47.9	+ 3.04	− 1	15	24.0	+ 2.46
β Aurigæ.................	5	53	8.9	+ 4.40	+44	56	22.9	+ 0.59
β Canis Majoris..........	6	18	52.1	+ 2.64	−17	54	43.1	− 1.65
α Canis Majoris (Sirius)...	6	41	18.9	+ 2.64	−16	35	46.2	− 4.80
ε Canis Majoris..........	6	55	12.4	+ 2.36	−28	51	11.0	− 4.78
α Can. Min. (Procyon)....	7	34	44.9	+ 3.14	+ 5	26	54.8	− 9.09
α Hydræ..................	9	23	18.8	+ 2.95	− 8	16	51.4	−15.51
α Leonis (Regulus).......	10	3	44.4	+ 3.20	+12	23	34.1	−17.52
α Ursæ Majoris...........	10	58	22.2	+ 3.73	+62	13	15.3	−19.40
β Leonis (Denebola)......	11	44	37.4	+ 3.06	+15	3	30.4	−20.12
ε Ursæ Majoris (Alioth) ..	12	50	12.3	+ 2.65	+56	25	54.8	−19.58
α Virginis (Spica).......	13	20	36.5	+ 3.16	−10	42	26.8	−18.85
α Boötis (Arcturus)......	14	11	41.6	+ 2.74	+19	38	5.7	−18.83
β Ursæ Minoris...........	14	50	56.9	− 0.21	+74	30	39.7	−14.72
α Scorpii (Antares)......	16	24	4.2	+ 3.67	−26	14	23.1	− 8.18
λ Scorpii................	17	27	41.9	+ 4.07	−37	2	28.3	− 2.84
α Ophiuchi...............	17	30	53.7	+ 2.78	+12	37	21.2	− 2.77
δ Ursæ Minoris...........	18	0	19.3	−19.50	+86	36	51.1	+ 0.08
α Lyræ (Vega)............	18	33	59.6	+ 2.03	+38	42	7.6	+ 3.24
α Cygni (Deneb)..........	20	38	27.9	+ 2.04	+44	58	8.3	+12.78
α Aquilæ (Altair)........	19	46	32.3	+ 2.93	+ 8	38	16.1	+ 9.37
α Pisc. Aust. (Fomalhaut)	22	52	50.8	+ 3.32	−30	5	1.1	+19.02
α Pegasi (Markab)........	23	0	25.6	+ 2.99	+14	44	13.1	+19.33

APPROXIMATE CORRECTION FOR REFRACTION

For Astronomical Observations

Corresponding to temperature of 50° F., and to a barometric pressure of 29.6 inches.

(From Young's General Astronomy, by permission.)

Altitude.	Refraction.		Altitude.	Refraction.		Altitude.	Refraction.	
°	′	″	°	′	″	°	′	″
0	34	50	11	4	47.7	30	1	39.5
1	24	22	12	4	24.5	35	1	22.1
2	18	06	13	4	04.4	40	1	08.6
3	14	13	14	3	47.0	45		57.6
4	11	37	16	3	18.2	50		48.3
5	9	45	18	2	55.5	55		40.3
6	8	23	20	2	37.0	60		33.2
7	7	19	22	2	21.6	65		26.8
8	6	29	24	2	08.6	70		20.9
9	5	49	26	1	57.6	80		10.2
10	5	16	28	1	48.0	90		0.0

For every 5° F. by which the temperature is less than 50° F., add one per cent to the tabular refraction, and decrease it in the same ratio for temperatures above 50° F.

Increase the tabular refraction by three and a half per cent for every inch of barometric pressure above 29.6 inches, and decrease it in the same ratio below that point. These corrections for temperature and pressure, though only approximate, will give a result correct within 2″ except in extreme cases.

DATA IN REGARD TO THE EARTH

(Radius, U. S. C. & G. Survey.)

Equatorial radius, 6,378,388 meters, 3,963,399 miles.
Polar radius, 6,365,909 meters, 3,949.992 miles.
1° latitude at the equator = 68.70 miles.
1° latitude at the pole = 69.41 miles.
Mean density of the earth, 5.52 g. per cu.cm.
Mean distance from the earth to the sun
149,500,000 kilometers,
92,900,000 miles.
Mean distance from the earth to the moon
384,393 kilometers,
238,854 miles.

DATA CONCERNING THE SOLAR SYSTEM

(Values from Young's General Astronomy, by permission.)

Name.	Mean dis. from sun, millions of miles.	Period in years.	Mean dia. in miles.	Mass, the earth =1.	Mean density, water =1.
Mercury	36.0	0.24	3030	0.047	4.70
Venus	67.2	0.62	7700	0.82	4.94
The earth	92.9	1.00	7917.6	1.000	5.55
Mars	141.5	1.88	4230	0.107	3.92
Jupiter	483.3	11.86	86500	317.7	1.32
Saturn	886.0	29.46	73000	94.8	0.72
Uranus	1781.9	84.02	31900	14.6	1.22
Neptune	2791.6	164.78	34800	17.0	1.11
Sun	....	....	866400	332000.	1.39
Moon	....	....	2163	0.0123	3.39

METEOROLOGICAL DATA

The Atmosphere

Total mass, estimated by Elkholm:
5.2×10^{21} grams.
11.4×10^{18} pounds.
Composition:
The total volume =1.

Substance.	Elevation.		
	Sea level.	10000 meters.	50000 meters.
Argon	0.009	0.006	0.0003
Carbon dioxide	0.0003	0.00015	0.0000
Helium	0.0000015	0.0000	0.00126
Hydrogen	0.0001	0.00035	0.136
Neon	0.000015	0.00002	0.0000
Nitrogen	0.780	0.812	0.792
Oxygen	0.210	0.182	0.070

Atmospheric Potential

The potential of the atmosphere increases with the elevation 130 to 200 volts per meter.

Velocity of Seismic Waves in the Earth's Crust

Longitudinal	4 to 14 kilometers per sec.
Transverse	3 to 10 kilometers per sec.

Angular Radius of Halos and Rainbows

Coronæ due to small water drops	1° to 10°
Small halo, due to 60° angles of ice crystals	22°
Large halo, due to 90° angles of ice crystals	46°
Rainbow, primary	41° 20′
Rainbow, secondary	52° 15′

Solar Constant

The energy falling on one sq.cm. area at normal incidence equals 1.92 small calories per minute.

ACCELERATION DUE TO GRAVITY, LATITUDE, LONGITUDE AND ELEVATION

United States

Station.	Latitude.			Longitude (Greenwich).			Elevation, meters.	g cm/sec.²
	°	′	″	°	′	″		
Atlanta, Ga.	33	44	58	84	23	18	324	979.523
Austin, Tex. (University)	30	17	11	97	44	14	189	979.282
Austin, Tex. (Capitol)	30	16	30	97	44	16	170	979.287
Baltimore, Md.	39	17	50	76	37	30	30	980.096
Boston, Mass.	42	21	33	71	03	50	22	980.395
Calias, Me.	45	11	11	67	16	54	38	980.630
Cambridge, Mass.	42	22	48	71	07	45	14	980.397
Charleston, S. C.	32	47	14	79	56	03	6	979.545
Charlottesville, Va.	38	02	01	78	30	16	166	979.937
Chicago, Ill.	41	47	25	87	36	03	182	980.277
Cincinnati, Ohio	39	08	20	84	25	20	245	980.003
Cleveland, Ohio	41	30	22	81	36	38	210	980.240
Colorado Springs, Colo.	38	50	44	104	49	02	1841	979.489
Deer Park, Md.	39	25	02	79	19	50	770	979.934
Denver, Colo.	39	40	36	104	56	55	1638	979.608
Ellsworth, Kansas	38	43	43	98	13	32	469	979.925
Ft. Egbert, Eagle, Alaska	64	47	22	141	12	24	174	982.182
Galveston, Texas	29	18	12	94	47	29	3	979.271
Grand Canyon, Wyo.	44	43	16	110	29	44	2386	979.898
Grand Junction, Colo.	39	04	09	108	33	56	1398	979.632
Green River, Utah	38	59	23	110	09	56	1243	979.635
Gunnison, Colo.	38	32	33	106	56	02	2340	979.341
Ithaca, N. Y.	42	27	04	76	29	00	247	980.299
Kansas City, Mo.	39	05	50	94	35	21	278	979.989
Key West, Fla.	24	33	33	81	48	25	1	978.969
Laredo, Texas	27	30	29	99	31	12	129	979.081
Little Rock, Ark.	34	44	57	92	16	24	89	979.720
Lower Geyser Basin, Wyo.	44	33	21	110	48	08	2200	979.931
Madison, Wis. (Univ. of Wis.)	43	04	35	89	24	00	270	980.364
New Orleans, La.	29	56	58	90	04	14	2	979.323
New York, N. Y.	40	48	27	73	57	43	38	980.266
Norris Geyser Basin, Wyo.	44	44	09	110	42	02	2276	979.949

ACCELERATION DUE TO GRAVITY, LATITUDE, LONGITUDE AND ELEVATION (Continued)

UNITED STATES (Continued)

Station.	Latitude. °	′	″	Longitude (Greenwich). °	′	″	Elevation, meters.	g cm/sec^2.
Philadelphia, Pa.	39	57	06	75	11	40	16	980.195
Pike's Peak, Colo.	38	50	20	105	02	02	4293	978.953
Pleasant Valley Junction, Utah	39	50	47	111	00	46	2191	979.511
Princeton, N. J.	40	20	57	74	39	28	64	980.177
Salt Lake City, Utah	40	46	04	111	53	46	1322	979.802
San Francisco, Cal.	37	47	00	124	46	00	114	979.965
St. Louis, Mo.	38	38	03	90	12	13	154	980.000
Terre Haute, Ind.	39	28	42	87	23	49	151	980.071
Wallace, Kans.	38	54	44	101	35	26	1005	979.754
Washington, C. & G. S.	38	53	13	77	00	32	14	980.111
Washington, Smithsonian	38	53	20	77	01	32	10	980.113
Worcester, Mass.	42	16	29	71	48	28	170	980.323

FOREIGN CITIES

Station.	Latitude. °	′	Longitute (Paris). °	′	Elevation, meters.	g cm/sec^2.
Berlin	+52	30	+ 11	4	38	981.287
Calcutta, India	+22	33	+ 86	1	6	978.822
Cape of Good Hope, Africa	−33	56	+ 16	9	11	979.659
Honolulu, Hawaii	+21	18	−160	12	3	978.966
London (Greenwich)	+51	17	− 2	12	48	981.188
Madrid	+40	24	− 6	1	656	979.981
Melbourne, Australia	−37	50	+142	38	27	979.985
Paris	+48	50	0	0	60	980.943
Rio de Janeiro, Brazil	−22	54	− 45	30	45	978.801
Rome	+41	54	+ 10	9	59	980.350
St. Petersburg	+59	56	+ 27	59	2	981.938
Shanghai, China	+31	12	+119	6	8	979.443
Stockholm	+59	21	+ 15	43	45	981.843
Tokio, Japan	+35	43	+137	26	18	979.801
Valparaiso, Chili	−33	2	− 73	58	0	979.630

MOMENT OF INERTIA FOR VARIOUS BODIES

The mass of the body is indicated by *m*.

Body.	Axis.	Moment of inertia.
Uniform thin rod	Normal to the length, at one end	$m\frac{l^2}{3}$
Uniform thin rod	Normal to the length, at the center	$m\frac{l^2}{12}$
Thin rectangular sheet, sides a and b	Through the center parallel to b	$m\frac{a^2}{12}$
Thin rectangular sheet, sides a and b	Through the center perpendicular to the sheet	$m\frac{a^2+b^2}{12}$
Thin circular sheet of radius r	Normal to the plate through the center	$m\frac{r^2}{2}$
Thin circular sheet of radius r	Along any diameter	$m\frac{r^2}{4}$
Thin circular ring. Plane figure formed by two concentric circles of radius r_1 and r_2	Through center normal to plane of ring	$m\frac{r_1^2+r_2^2}{2}$
Thin circular ring. Plane figure formed by two concentric circles of radius, r_1 and r_2	Any diameter	$m\frac{r_1^2+r_2^2}{4}$
Rectangular parallelopiped, edges a, b, and c	Through center perpendicular to face ab, (parallel to edge c)	$m\frac{a^2+b^2}{12}$
Sphere, radius r	Any diameter	$m\frac{2}{5}r^2$
Spherical shell, external radius, r_1 internal, radius r_2	Any diameter	$m\frac{2}{5}\frac{(r_1^5-r_2^5)}{(r_1^3-r_2^3)}$

MOMENT OF INERTIA FOR VARIOUS BODIES (Continued)

The mass of the body is indicated by m.

Body.	Axis.	Moment of inertia.
Spherical shell, very thin, mean radius, r	Any diameter	$m\frac{2r^2}{3}$
Right circular cylinder of radius r, length l	The longitudinal axis of the solid	$m\frac{r^2}{2}$
Right circular cylinder of radius r, length l	Through center perpendicular to the axis of the figure, (transverse diameter)	$m\left(\frac{r^2}{4}+\frac{l^2}{12}\right)$
Hollow circular cylinder, length l, external radius r_1 internal radius r_2	The longitudinal axis of the figure	$m\frac{(r_1^2+r_2^2)}{2}$
Thin cylindrical shell, length l, mean radius, r	The longitudinal axis of the figure	mr^2
Hollow circular cylinder, length l, external radius r, internal radius r_2	Transverse diameter	$m\left[\frac{r_1^2+r_2^2}{4}+\frac{l^2}{12}\right]$
Hollow circular cylinder, length l, very thin, mean radius r	Transverse diameter	$m\left(\frac{r^2}{2}+\frac{l^2}{12}\right)$
Elliptic cylinder, length l, transverse semiaxes a and b	Longitudinal axi:	$m\left(\frac{a^2+b^2}{4}\right)$
Right cone, altitude h, radius of base r	Axis of the figure	$m\frac{3}{10}r^2$
Spheroid of revolution, equatorial radius r	Polar axis	$m\frac{2r^2}{5}$
Ellipsoid, axes $2a$, $2b$, $2c$	Axis $2a$	$m\frac{(b^2+c^2)}{5}$

ACCELERATION DUE TO GRAVITY AND LENGTH OF THE SECONDS PENDULUM

For Sea Level at Different Latitudes

Latitude.	g cm./sec.^{2}	g ft./sec.^{2}	Length in cm.	Length in ins.
0°	977.989	32.0862	99.0910	39.0121
5	8.029	.0875	.0950	.0137
10	.147	.0916	.1079	.0184
15	.339	.0977	.1265	.0261
20	.600	.1062	.1529	.0365
25	978.922	32.1168	99.1855	39.0493
30	9.295	.1290	.2234	.0642
31	.374	.1316		
32	.456	.1343		
33	.538	.1370		
34	979.622	32.1398		
35	.707	.1425	.2651	.0806
36	.793	.1454		
37	.880	.1490		
38	.968	.1511		
39	980.057	32.1540		
40	.147	.1570	.3096	.0982
41	.237	.1607		
42	.327	.1630		
43	.418	.1659		
44	980.509	32.1688		
45	.600	.1719	.3555	.1163
46	.691	.1748		
47	.782	.1778		
48	.873	.1808		
49	980.963	32.1838		
50	1.053	.1867	99.4014	39.1344
51	.143	.1896		
52	.231	.1924		
53	.318	.1954		
54	981.407	32.1983		
55	.493	.2011	.4459	.1520
56	.578	.2039		
57	.662	.2067		
58	.744	.2094		
59	981.825	32.2121		
60	.905	.2147	.4876	.1683
65	2.278	.2276	.5255	.1832
70	.600	.2375	.5581	.1960
75	.861	.2460	99.5845	39.2065
80	983.053	32.2523	.6040	.2141
85	.171	.2562	.6160	.2188
90	.210	.2575	.6200	.2204

MISCELLANEOUS CONSTANTS

Mean radius of the earth, 6.371×10^8 cm. = 6371 kilometers.

1 degree of latitude at 40° = 69 miles.

1 knot or nautical mile = 1′ of arc on the earth's surface at the equator.

Mean density of the earth, 5.52 grams per cu.cm.

Constant of gravitation, $K = 6.667 \times 10^{-8}$ = the attraction in dynes between two gram masses one centimeter apart.

Acceleration due to gravity at sea level, lat. 45° = 980.60 cm. per sec. per sec. = 32.172 feet per sec. per sec.

Length of seconds pendulum at sea level, lat. 45° = 99.356 cm. = 39.116 in.

Density of mercury at 0° C. = 13.5955 g. per c.c.

Density of water, maximum at 3.98° C. = 0.999973 g. per c.c.

Density of dry air at 0° C. and 760 mm. = .001293 g. per c.c.

Velocity of sound in dry air at 0° C., 33,136 cm. per sec. = 1089 feet per sec.

Velocity of light in a vacuum = 2.9989×10^{10} cm. per sec. = 984×10^6 feet per sec.

Heat equivalent of fusion of water 79.24 cal. per gram.

Heat equivalent of vaporization of water, 535.9 cal. per gram.

Coefficient of expansion of gases, .003665.

Specific heat of air, at constant pressure, 0.238.

Electrochemical equivalent of silver, 0.001118 g. per sec. per ampere.

Mean wave length of sodium light, .00005893 cm. or 5893. ångström units.

Absolute wave length of red cadmium line in air, 760 mm. pressure, 15° C., ångström units: 6438.4722 (Michelson); 6438.4696 (Fabry and Perot).

GREEK ALPHABET

Greek letter	Greek name	English equivalent	Greek letter	Greek name	English equivalent
Α α	Alpha	a	Ν ν	Nu	n
Β β	Beta	b	Ξ ξ	Xi	x
Γ γ	Gamma	g	Ο ο	Omicron	ŏ
Δ δ	Delta	d	Π π	Pi	p
Ε ε	Epsilon	ĕ	Ρ ρ	Rho	r
Ζ ζ	Zeta	z	Σ σ	Sigma	s
Η η	Eta	ē	Τ τ	Tau	t
Θ θ	Theta	th	Υ υ	Upsilon	u
Ι ι	Iota	i	Φ φ	Phi	ph
Κ κ	Kappa	k	Χ χ	Chi	ch
Λ λ	Lambda	l	Ψ ψ	Psi	ps
Μ μ	Mu	m	Ω ω	Omega	ō

DEFINITIONS AND FORMULÆ

FUNDAMENTAL CHEMICAL LAWS

Scientific laws are statements of facts which have been established by direct experiment.

Boyle's Law for Gases.—At a constant temperature the volume of a given quantity of any gas varies inversely as the pressure to which the gas is subjected. This idea is expressed in the following formulæ:

$$PV = \text{a constant}, \quad \text{or} \quad P = 1/V, \quad \text{or} \quad V = 1/P, \quad \text{or} \quad PV = P_1V_1$$

The Law of Combining Weights.—If the weights of elements which combine with each other be called their "combining weights," then elements always combine either in the ratio of their combining weights or of simple multiples of these weights.

Law of Definite Proportions.—In every sample of each compound substance the proportions by weight of the constituent elements are always the same.

Dalton's Law of Partial Pressures.—The pressure exerted by a mixture of gases is equal to the sum of the separate pressures which each gas would exert if it alone occupied the whole volume. This fact is expressed in the following formula:

$$PV = V(p_1 + p_2 + p_3, \text{ etc.})$$

Faraday's Law.—The amounts of decomposition effected by the passage of equal quantities of electricity through them are, for the same electrolyte, equal, and for different electrolytes are proportional to the combining weights of the elements or radicles which are deposited.

Gay-Lussac's Law for Gases (or Charles' Law).—At a constant pressure, the volume of a given quantity of any gas increases about 1/273 of its volume at 0° C. for each rise of 1° C. and at constant volume the pressure of a given quantity of any gas increases about 1/273 of the pressure at 0° C. for each rise of 1° C. in temperature.

Gay-Lussac's Law of Combining Volumes.—If gases interact and form a gaseous product, the volumes of the reacting gases and the volumes of the gaseous products are to each other in very simple proportions, which can be expressed by small whole numbers.

Hess' Law of Constant Heat Summation.—The amount of heat generated by a chemical reaction is the same whether reaction takes place in one step or in several steps, or all chemical reactions which start with the same original substances, and end with the same final substances, liberate the same amounts of heat, irrespective of the process by which the final state is reached.

Henry's Law.—The amount of gas which a liquid will dissolve is directly proportional to the pressure of the gas. This holds for all gases which do not unite chemically with the solvent.

The Law of Mass Action.—At a constant temperature the product of the active masses on one side of a chemical equation when divided by the product of the active masses on the other side of the chemical equation is a constant, regardless of the amounts of each substance present at the beginning of the action.

Law of Multiple Proportions.—Two elements may combine in more than one proportion by weight, but if so, the weights of one element which combine with a fixed weight of the other element, are always in a simple ratio to each other.

The Periodic Law.—The physical and chemical properties of the elements are functions of their atomic weights, and most of these properties are periodic functions of the atomic weights.

FUNDAMENTAL CHEMICAL THEORIES

A scientific hypothesis is an endeavor to form a rational mental picture of the causes which lead to a group of observed facts even though these causes may not be subject to direct proof.

A scientific theory is an hypothesis whose consequences have been so thoroughly tested by experiment that it has become generally accepted as the correct explanation for a group of facts.

The Atomic Theory.—All elementary forms of matter are composed of very small unit quantities called atoms. The atoms of a given element all have the same size and weight. The atoms of different elements have different size and weight. Atoms of the same or different elements unite with each other to form very small unit quantities of compound substances called molecules.

Avogadro's Theory.—Equal volumes of all gases under the same conditions of temperature and pressure contain equal numbers of molecules.

The Electrolytic Dissociation or Ionization Theory.—When an acid, base or salt is dissolved in water or any other dissociating solvent, a part or all of the molecules of the dissolved substance are broken up into parts called ions, some of which are charged with positive electricity and are called cations, and an equivalent number of which are charged with negative electricity and are called anions.

Electrolytic Solution Tension Theory (or the Helmholtz Double Layer Theory).—When a metal, or any other substance capable of existing in solution as ion is placed in water or any other dissociating solvent, a part of the metal or other substance passes into solution in the form of ions, thus leaving the remainder of the metal or substance charged with an equivalent amount of electricity of opposite sign from that carried by the ions. This establishes a difference in potential between the metal and the solvent in which it is immersed.

The Electron Theory.—An atom of any element consists of a definite number of unit negative charges of electricity moving in orbits inside the atom with velocities which approach the velocity of light.

DEFINITION OF CHEMICAL TERMS

An Acid is any substance which yields hydrogen ions.

The Active Mass of a substance is the number of gram-molecular-weights per liter in solution, or in gaseous form.

Adsorption. The ability of a solid to condense gases, liquids, or dissolved substances on their surfaces is called adsorption. It is a manifestation of the force of adhesion.

An Atom is the smallest unit quantity of an element that is capable of entering into chemical combination.

A Base is any substance which yields hydroxyl ions.

A Balanced or Reversible Action is one which can be caused to proceed in either direction by suitable variation in the conditions of temperature, volume, pressure or of the quantities of reacting substances.

A Catalytic Agent is a substance which by its mere presence alters the velocity of a reaction, and may be recovered unaltered in nature or amount at the end of the reaction.

A Colligative Property is a property numerically the same for a group of substances, independent of their chemical nature.

A Constitutive Property is a property which depends on the constitution or structure of the molecule.

A Cryohydrate is the solid which separates when a saturated solution freezes. It contains the solvent and the solute in the same proportions as they were in the saturated solution.

The Combining Weight of an element or radicle is its atomic weight divided by its valence.

A Eutectic is that alloy of two or more metals which has the lowest melting point.

The Hydrogen Equivalent of a substance is the number of replaceable hydrogen atoms in 1 molecule or the number of atoms of hydrogen with which 1 molecule could react.

The Heat of Combustion of a substance is the amount of heat evolved by the combustion of 1 gram molecular weight of the substance.

An Ion is a charged atom or group of atoms in solution. Solutions always contain equivalent numbers of positive and negative ions.

A Molecule is the smallest unit quantity of matter which can exist by itself and retain all the properties of the original substance.

A Molar Solution contains 1 gram molecular weight of dissolved substance per liter of solution.

A Normal Solution contains 1 gram molecular weight of dissolved substance divided by the hydrogen equivalent of the substance per liter of solution.

Oxidation is any process which increases the proportion of oxygen or acid-forming element or radicle in a compound.

Reduction is any process which increases the proportion of hydrogen or base-forming elements or radicle in a compound.

A Salt is any substance which yields ions, other than hydrogen or hydroxyl ions.

The Solubility Product or precipitation value is the product of the concentrations of the ions of a substance in a saturated solution of the substance.

ONE HUNDRED COMPLETED CHEMICAL EQUATIONS

1. $H_2PtCl_6 + 2KCl = 2HCl + K_2PtCl_6$
2. $K_2PtCl_6 + \text{heat} = 2KCl + Pt + 2Cl_2$
3. $KHC_4H_4O_6 + NaOH = KNaC_4H_4O_6 + H_2O$
4. $Na_2O_2 + 2H_2O = 2NaOH + H_2O_2$
5. $2KMnO_4 + 4H_2SO_4 + 5H_2O_2 = 2KHSO_4 + 2MnSO_4 + 8H_2O + 5O$
6. $2KI + H_2O_2 = 2KOH + I_2$
7. $2AuCl_3 + 3H_2O_2 + 6NaOH = 6NaCl + 6H_2O + 3O_2 + 2Au$
8. $MnCl_2 + 2KOH + H_2O_2 = 2KCl + H_2O + MnO \cdot (OH)_2$ (brown)
9. $2NiCl_2 + 4KOH + H_2O_2 = 4KCl + 2Ni(OH)_3$ (black)
10. $2CoCl_2 + 4KOH + H_2O_2 = 4KCl + 2Co(OH)_3$ (black)
11. $MgCl_2 + Na_2HPO_4 + NH_3 = 2NaCl + MgNH_4PO_4$
12. $2BaCl_2 + K_2Cr_2O_7 + H_2O = 2BaCrO_4 + 2HCl + 2KCl$
13. $AlCl_3 + 3KOH = 3KCl + Al(OH)_3$
14. $Al(OH)_3 + 3KOH = 3H_2O + Al(OK)_3$
15. $2AlCl_3 + 3Na_2S_2O_3 + 3H_2O = 6NaCl + 3S + 3SO_2 + 2Al(OH)_3$
16. $2CrCl_3 + 3(NH_4)_2S + 6H_2O = 6NH_4Cl + 3H_2S + 2Cr(OH)_3$
17. $CrCl_3 + 8NaC_2H_3O_2 + 4H_2O + 3Cl = 6NaCl + 8HC_2H_3O_2 + Na_2CrO_4$
18. $2CrCl_3 + 3MnO_2 + 2H_2O = 3MnCl_2 + 2H_2CrO_4$
19. $K_2Cr_2O_7 + 2KOH = H_2O + 2K_2CrO_4$
20. $K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 = 7H_2O + K_2SO_4 + 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3$
21. $K_2Cr_2O_7 + 6HI + 4H_2SO_4 = K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 6I$
22. $K_2Cr_2O_7 + 14HCl = 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$
23. $FeCl_2 + 2KCN = 2KCl + Fe(CN)_2$
24. $FeCN_2 + 4KCN = K_4[Fe(CN)_6]$
25. $FeCl_3 + 3NaC_2H_3O_2 = 3NaCl + Fe(C_2H_3O_2)_3$
26. $Fe(C_2H_3O_2)_3 + 2H_2O = 2HC_2H_3O_2 + Fe(OH)_2(C_2H_3O_2)$
27. $K_4[Fe(CN)_6] + 6H_2SO_4 + 6H_2O = 2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6CO$
28. $2MnO_2 + 8HCl = 4H_2O + 2MnCl_2 + 2Cl_2$
29. $2MnSO_4 + 5PbO_2 + 6HNO_3 = 2PbSO_4 + 3Pb(NO_3)_2 + 2H_2O + 2HMnO_4$
30. $2HMnO_4 + 14HCl = 8H_2O + 2MnCl_2 + 5Cl_2$
31. $MnSO_4 + 2Na_2CO_3 + O_2 = 2CO_2 + Na_2SO_4 + Na_2MnO_4$
32. $2KMnO_4 + 10FeSO_4 + 8H_2SO_4 = K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$
33. $2KMnO_4 + 3MnSO_4 + 2H_2O = K_2SO_4 + 5MnO_2 + 2H_2SO_4$
34. $NiCl_2 + 6NH_3 = Ni(NH_3)_6Cl_2$
35. $NiCl_2 + 2KCN = 2KCl + Ni(CN)_2$
36. $Ni(CN)_2 + 2KCN = K_2Ni(CN)_4$
37. $CoCl_2 + 2KNO_2 = Co(NO_2)_2 + 2KCl$
38. $Co(NO_2)_2 + 2HNO_2 = H_2O + NO + Co(NO_2)_3$
39. $Co(NO_2)_3 + 3KNO_2 = K_3Co(NO_2)_6$
40. $3Zn + 8HNO_3 = 3Zn(NO_3)_2 + 4H_2O + 2NO$
41. $Zn + 2KOH = K_2ZnO_2 + H_2$
42. $Zn(OH)_2 + 2NH_4Cl + 4NH_3 = Zn(NH_3)_6Cl_2 + 2H_2O$
43. $ZnCl_2 + 2KCN = 2KCl + Zn(CN)_2$

44. $Zn(CN)_2 + 2KCN = K_2Zn(CN)_4$
45. $3Hg + 8HNO_3 = 3Hg(NO_3)_2 + 4H_2O + 2NO$
46. $HgCl_2 + 2NH_3 = NH_4Cl + HgNH_2Cl$
47. $3HgCl_2 + 2H_2S = 4HCl + Hg_3Cl_2S_2$ (white)
48. $Hg_3Cl_2S_2 + H_2S = 2HCl + 3HgS$
49. $3Hg(NO_3)_2 + 6FeSO_4 = 2Fe(NO_3)_3 + 2Fe_2(SO_4)_3 + 3Hg$
50. $2HgCl + 2NH_3 = NH_4Cl + HgNH_2Cl + Hg$
51. $Hg_2(NO_3)_2 + H_2S = 2HNO_3 + HgS + Hg$
52. $Hg_2(NO_3)_2 + 2KCN = 2KNO_3 + Hg(CN)_2 + Hg$
53. $Pb(NO_3)_2 + 2KOH = Pb(OH)_2 + 2KNO_3$
54. $Pb(OH)_2 + 2KOH = K_2PbO_2 + 2H_2O$
55. $2PbCl_2 + H_2S = 2HCl + PbCl_2.PbS$ (orange)
56. $PbCl_2.PbS + H_2S = 2PbS + 2HCl$
57. $3PbS + 8HNO_3 = 3Pb(NO_3)_2 + 4H_2O + 2NO + 3S$
58. $BiCl_3 + H_2O = 2HCl + BiOCl$
59. $SnCl_2 + 2KOH = 2KCl + Sn(OH)_2$ (white ppt.)
60. $Sn(OH)_2 + 2KOH = K_2SnO_2 + 2H_2O$ (soluble)
61. $2BiCl_3 + 6KOH = 2Bi(OH)_3 + 6KCl$
62. $2Bi(OH)_3 + 3K_2SnO_2 = 3H_2O + 3K_2SnO_3 + Bi_2$ (black)
63. $3Cu + 8HNO_3 = 4H_2O + 3Cu(NO_3)_2 + 2NO$
64. $Cu + H_2SO_4 = H_2O + SO_2 + CuO$
65. $CuO + H_2SO_4 = CuSO_4 + H_2O$
66. $2CuSO_4 + 2NH_4OH = (NH_4)_2SO_4 + Cu_2SO_4 \cdot (OH)_2$
67. $Cu_2SO_4(OH)_2 + (NH_4)_2SO_4 + 6NH_3 = 2[Cu(NH_3)_4](SO_4) . H_2O$ (soluble, blue)
68. $2Cu(NH_3)_4SO_4 . H_2O + 9KCN = Cu_2(CN)_8NH_4 . K_5 + 2K_2SO_4 + 6NH_3 + NH_4CNO$
69. $Cd(NO_3)_2 + 2KCN = 2KNO_3 + Cd(CN)_2$
70. $Cd(CN)_2 + 2KCN = K_2Cd(CN)_4$
71. $K_2Cd(CN)_4 + H_2S = 2KCN + 2HCN + CdS$
72. $H_3AsO_4 + H_2S = H_2O + S + H_3AsO_3$
73. $2H_3AsO_3 + 3H_2S = 6H_2O + As_2S_3$
74. $As_2S_3 + 3(NH_4)_2S = 2(NH_4)_3AsS_3$
75. $2(NH_4)_3AsS_3 + 6HCl = 6NH_4Cl + As_2S_3 + 3H_2S$
76. $As_2S_5 + 3(NH_4)_2S = 2(NH_4)_3AsS_4$.
77. $2(NH_4)_3AsS_4 + 6HCl = As_2S_5 + 3H_2S + 4NH_4Cl$. Antimony reactions same as arsenic
78. $3Sn + 4HNO_3 = H_2O + 3H_2SnO_3 + 4NO$
79. $SnCl_2 + H_2S = SnS + 2HCl$
80. $SnS + (NH_4)_2S_2 = (NH_4)_2SnS_3$
81. $(NH_4)_2SnS_3 + 2HCl = 2NH_4Cl + H_2S + SnS_2$
82. $SnCl_4 + 2H_2S = SnS_2 + 4HCl$
83. $SnS_2 + (NH_4)_2S = (NH_4)_2SnS_3$
84. $SnO_2 + 2KCN = 2KCNO + Sn$ (fusion)
85. $2Au + 2HNO_3 + 6HCl = 4H_2O + 2NO + 2AuCl_3$
86. $2AgNO_3 + 2KOH = 2KNO_3 + H_2O + Ag_2O$
87. $Ag_2O + 2NH_4OH = 2(AgNH_3)OH + H_2O$
88. $AgCl + 2NH_4OH = 2Ag(NH_3)_2Cl$
89. $AgCl + 2KCN = KAg(CN)_2 + KCl$
90. $6NH_4OH + 2NH_3 + 3Cl_2 = 6H_2O + 6NH_4Cl + N_2$
91. $6NaOH + 3Cl_2 = 5NaCl + NaClO_3 + 3H_2O$
92. $H_2SO_4 + 2HI = H_2O + H_2SO_3 + I_2$

93. $H_2SO_4+8HI=4H_2O+H_2S+4I_2$
94. $2Na_2S_2O_3+I_2=2NaI+Na_2S_4O_6$
95. $H_3PO_4+12(NH_4)_2MoO_4+21HNO_3=(NH_4)_3PO_4.12MoO_3+21(NH_4)NO_3+12H_2O$
96. $(NH_4)_3PO_4.12MoO_3+24NH_4OH=(NH_4)_3PO_4+12(NH_4)_2MoO_3+12H_2O$
97. $6FeSO_4+3H_2SO_4+2HNO_3=3Fe_2(SO_4)_3+4H_2O+2NO$
98. $Fe(NO_3)_2+NO=Fe(NO_3)_2NO$
99. $KClO_3+3H_2SO_4+6FeSO_4=3Fe_2(SO_4)_3+3H_2O+KCl$
100. $Na_2SiO_3+2NH_4Cl+2H_2O=2NaCl+2NH_4OH+H_2SiO_3$

PHYSICAL TERMS, QUANTITIES AND UNITS

Mechanics

Unit of Time.—The second, 1/86400 of a mean solar day. One of the three fundamental units of the C. G. S. system.

Unit of Length.—The centimeter, 1/100 the length of the International Prototype Meter, at Paris, at zero degrees centigrade. One of the three fundamental units of the C. G. S. system. The standard in the British system is the yard, the prototype of which is kept by the British government. The United States standard yard is defined as 3600/3937 meter.

Unit of Area.—The square centimeter. The area of a square whose sides are one centimeter in length. Other units of area are similarly derived.

Unit of Volume.—The cubic centimeter, the volume of a cube whose edges are one centimeter in length. Other units of volume are derived in a similar manner.

Mass.—Quantity of matter.

Units of Mass.—The gram is 1/1000 the quantity of matter in the International Prototype Kilogram; one of the three fundamental units of the C. G. S. system. The British standard of mass is the pound, of which a standard is preserved by the government. The United States standard mass is the avoirdupois pound defined as 1/2.20462 kilogram.

Inertia.—The resistance offered by a body to a change of its state of rest or motion. A particular aspect of a mass; the terms are practically synonymous.

Density.—Concentration of matter, measured by the mass per unit volume, expressed as grams per cubic centimeter.

Specific Gravity.—The ratio of the mass of a body to the mass of an equal volume of water at 4° C.

Angle.—The ratio between the arc and the radius of the arc.

Units of Angle.—The radian, the angle subtended by an arc equal to the radius; the degree, 1/360 part of a circumference.

Solid Angle.—Measured by the ratio of the surface of the portion of a sphere enclosed by the conical surface forming the angle, to the square of the radius of the sphere.

Unit of Solid Angle.—The steradian, the solid angle which encloses a surface on the sphere equivalent to the square of the radius.

Speed.—Time rate of motion measured by the distance moved over in unit time. Unit—one centimeter per second.

Velocity.—Time rate of motion in a fixed direction. Unit—one centimeter per second.

Angular Velocity.—Time rate of angular motion about a center. Unit—one radian per second.

Acceleration.—The time rate of change of velocity either in speed or direction measured by the change in unit time. Unit—one centimeter per second per second.

Angular Acceleration.—The time rate of change of angular velocity. Unit—one radian per second per second.

Momentum.—Quantity of motion measured by the product of mass and velocity. Unit—one gram-centimeter per second.

Angular Momentum or Moment of Momentum.—Quantity of angular motion measured by the product of the angular velocity and the moment of inertia. Unit—unnamed, its nature is expressed by $g.cm^2/sec$.

Force.—That which changes the state of rest or motion in matter, measured by the rate of change of momentum. Unit—the dyne, the force which will produce the change of velocity of one centimeter per second in a gram mass in one second.

Moment of Force or Torque.—The effectiveness of a force to produce rotation about a center, measured by the product of the force and the perpendicular distance from the line of action of the force to the center. Unit—the dyne-centimeter.

Gravitation.—The universal attraction existing between all material bodies.

Acceleration Due to Gravity.—The acceleration of a body freely falling in a vacuum. Unit—one centimeter per second per second.

Weight.—The force with which a body is attracted toward the center of the earth. The weight of any fixed mass varies according to its geographical position.

Unit of Weight.—The dyne.

Moment of Inertia.—A measure of the effectiveness of mass in rotation. In the rotation of a rigid body not only the body's mass, but the distribution of the mass about the axis of rotation determines the change in the angular velocity resulting from the action of a given torque for a given time. Moment of inertia in rotation is analogous to mass (inertia) in simple translation. The unit is $g.\ cm.^2$

Period in uniform circular motion is the time of one complete revolution.

Centripetal Force.—The force required to keep a moving mass in a circular path. Centrifugal force is the name given to the outward force of a mass in rotation.

Simple Harmonic Motion.—If a point move uniformly in a circle, the motion of its projection on the diameter (or any straight line in the same plane) is simple harmonic motion.

Displacement at any instant. The distance of a vibrating or oscillating particle from its position of equilibrium or the center of the circle of reference.

Amplitude. — The maximum value of the displacement.

Phase.—The fraction of a whole period which has elapsed since the moving particle last passed through its middle position in a positive direction.

Work.—When a force acts against resistance to produce motion in a body the force is said to do work. Work is measured by the product of the force acting and the distance moved through against the resistance.

Units of Work.—The erg, a force of one dyne acting through one centimeter. The joule is 10^7 ergs.

Power.—The time rate at which work is done.

Units of Power.—The watt, one joule (one million ergs) per second; the kilowatt is equal to 1000 watts; the horse-power, 33,000 foot-pounds per minute, is equal to 746 watts.

Energy.—The capability of doing work. Units of energy the same as of work.

Potential Energy.—Energy due to position of one body with respect to another or to the relative parts of the same body.

Kinetic Energy.—Energy due to motion.

Simple Machine.—A contrivance for the transfer of energy and for increased convenience in the performance of work.

Mechanical advantage of a machine is the ratio of the distance through which force is applied to the distance through which resistance is overcome, also called the velocity ratio.

Efficiency is the ratio of the work done by a machine to the work done upon it.

Elasticity.—The property by virtue of which a body recovers from deformation produced by force.

Stress.—The force producing or tending to produce deformation in the body measured by the force applied per unit area. Unit—one dyne per square centimeter.

Strain.—The deformation resulting from a stress measured by the ratio of the change to the total value of the dimension in which the change occurred.

Modulus of Elasticity.—The stress required to produce unit strain, which may be a change of length (Young's modulus); a twist or shear (modulus of rigidity) or of volume (bulk modulus).

Limit of Elasticity.—The smallest value of the stress producing permanent alteration.

Coefficient of Restitution of two bodies on impact, the ratio of the difference in velocity before impact to the difference after impact.

Viscosity.—All liquids possess a definite resistance to change of form and many solids show a gradual yielding to forces tending to change their form. This property is called viscosity.

Pressure.—Force applied to, or distributed, over a surface; measured as force per unit area. Unit—the barye, one dyne per square centimeter. The mega-barye is equal to 10^6 dynes per square centimeter. Pressure is also measured by the height of the column of mercury or water which it supports.

Surface Tension.—The tension exhibited by the free surface of liquids measured in dynes per centimeter.

Heat

Temperature.—The condition of a body which determines the transfer of heat to or from other bodies. The unit of temperature is the Centigrade degree, 1/100 the difference in temperature between that of melting ice and boiling water at 76 centimeters pressure. The degree Fahrenheit is 1/180 and the degree Reaumur is 1/80 the above-mentioned difference of temperature.

Heat Quantity is measured by the change of temperature produced. The unit of heat is the calorie, the quantity of heat necessary to change the temperature of one gram of water from 3.5° C. to 4.5° C. (called a small calorie). If the temperature changed involved is from 14.5 to 15.5° C. the unit is the normal calorie. The mean calorie is 1/100 the quantity of heat necessary to raise one gram of water from 0° C. to 100° C. The large calorie is equal to 1000 small calories. The British thermal unit is the heat required to raise the temperature of one pound of water at its maximum density, 1° F. It is equal to 252 calories.

Coefficient of Thermal Expansion.—The coefficient of linear expansion is the ratio of the change in length per degree to the length at 0° C. The coefficient of surface expansion is two times the linear coefficient. The coefficient of volume expansion (for solids) is three times the linear coefficient. The coefficient of volume expansion for liquids is the ratio of the change in volume per degree to the volume at 0° C. The value of the coefficient varies with temperature. The coefficient of volume expansion for a gas under constant pressure is nearly the same for all gases and temperatures and is equal to 0.00367 for 1° C.

Absolute Zero.—The temperature at which a gas would show no pressure if the general law for gases should hold for all temperatures. It is equal to −273° C. or −459.4° F.

Specific Heat.—The quantity of heat necessary to cause a unit change of temperature in unit mass measured in C. G. S. units as calories per gram per degree centigrade.

Thermal Capacity or Water Equivalent.—The total quantity of heat necessary to raise any body or system unit temperature, measured as calories per degree centigrade in the C. G. S. system.

Heat Equivalent, or Latent Heat, of Fusion.—The quantity of heat necessary to change one gram of solid to a liquid with no temperature change.

Latent Heat of Vaporization.—The quantity of heat necessary to change one gram of liquid to vapor without change of temperature. Both the above quantities are measured as calories per gram.

Thermal Conductivity.—Time rate of transfer of heat by conduction, through unit thickness, across unit area for unit difference of temperature. It is measured as calories per second per square centimeter for a thickness of one centimeter and a difference of temperature of 1° C.

Mechanical Equivalent of Heat is the quantity of energy

which, when transformed into heat, is equivalent to unit quantity of heat, 4.18×10^7 ergs = 1 calorie (20° C.).

Isothermal.—When a gas passes through a series of pressure and volume variations without change of temperature the changes are called iosthermal. A line on a pressure-volume diagram representing these changes is called an isothermal line.

Adiabatic.—A body is said to undergo an adiabatic change when its condition is altered without gain or loss of heat. The line on the pressure-volume diagram representing the above change is called an adibatic line.

Entropy.—A quantity depending on the quantity of heat in a body and on its temperature, which, when multiplied by any lower temperature (minimum available), gives the unavailable energy or unavoidable waste when mechanical work is derived from the heat energy of the body.

Absolute Humidity.—Mass of water vapor present in the atmosphere measured as grams per cubic meter.

Relative Humidity. —The ratio of the quantity of water vapor present in the atmosphere to the quantity which would saturate at the existing temperature.

Wave Motion and Sound

Wave Motion.—A progressive disturbance propagated in a medium by the periodic vibration of the particles of the medium. Transverse wave motion is that in which the vibration of the particles is perpendicular to the direction of propagation. Longitudinal wave motion is that in which the vibration of the particles is parallel to the direction of propagation.

Pitch of sound is determined by the frequency or number of vibrations per second.

Intensity or loudness of a sound increases or diminishes with the amplitude of the vibrating air particles at the ear.

Quality or timbre of a sound depends on the coexistence with the fundamental of other vibrations of various frequencies and amplitudes.

Lissajou's Figures.—The path described by a particle which is simultaneously displaced by two simple harmonic motions at right angles, when the periods of the two motions are in the ratio of two small whole numbers, shows a variety of characteristic curves called Lissajou's figures.

Beats.—Two tones of slightly different frequencies sounded together interfere to give a sound of regularly varying intensity. The number of beats per second is the difference in frequency of the two tones.

Static Electricity

Unit Quantity of electricity or charge is the quantity which, when concentrated at a point and placed at unit distance from an equal and similarly concentrated quantity, is repelled with unit force. If the distance is one centimeter and the force of repulsion one dyne and the surrounding medium a vacuum,

we have the electrostatic unit of quantity. The coulomb = 3×10^9 electrostatic units.

Line of Force.—A line such that its direction at every point is the same as the direction of the force which would act on a small positive charge placed at that point. A line of force is supposed to start from a positive charge and end on a negative charge.

Conductors.—A class of bodies which are incapable of supporting electric strain. A charge given to a conductor spreads to all parts of the body.

Dielectrics or Insulators or Non-Conductors.—A class of bodies supporting an electric strain. A charge on one part of a non-conductor is not communicated to any other part.

Electric Surface Density.—Quantity of electricity per unit area.

Intensity of Electric Field is measured by the force exerted on unit charge. Unit field intensity is the field which exerts the force of one dyne on unit positive charge.

Electric Potential at any point is measured by the work necessary to bring unit positive charge from an infinite distance. Difference of potential between two points is measured by the work necessary to carry unit positive charge from one to the other. If the work involved is one C. G. S. unit of work we have the electrostatic unit of potential.

Electromotive Force.—The same as difference of potential, a term commonly used in current electricity. The **volt** is the electromotive force which performs work at the rate of one joule per second (one watt) in producing a current of one ampere. A watt hour is the work equivalent to a current of one ampere at a pressure of one volt flowing for one hour. A kilowatt hour equals 1000 watt hours. A volt equals 10^8 electrostatic units of potential.

Capacity is measured by the charge which must be communicated to a body to raise its potential one unit. Electrostatic unit capacity is that which requires one electrostatic unit of charge to raise its potential one electrostatic unit. The farad = 9×10^{11} electrostatic units.

Specific Inductive Capacity.—The ratio of the capacity of a condensor with a given substance as dielectric to the capacity of the same condensor with air or a vacuum as dielectric is called the specific inductive capacity.

Magnetism

Unit Magnetic Pole or Quantity of Magnetism.—Two unit quantities of magnetism concentrated at points unit distance apart in a vacuum repel each other with unit force. If the distance involved is one centimeter and the force one dyne the quantity of magnetism at each point is one C. G. S. unit of magnetism.

Surface Density of Magnetism.—Quantity of magnetism per unit area.

Magnetic Line of Force is a line which at every point has the direction of the magnetic force at that point.

Magnetic Field Intensity is measured by the force acting on unit magnetic pole. The unit of magnetic field intensity, the gauss, is that field which exerts a force of one dyne on unit magnetic pole.

Magnetic Moment of a magnet is given by the product of the quantity of magnetism in each pole by the distance between the poles.

Intensity of Magnetization is given by the quotient of magnetic moment of a magnet by its volume or it is magnetic moment per unit volume.

Declination.—The angle between the vertical plane containing the direction of the earth's field at any point and a plane containing the geographic north and south meridian.

Dip.—The angle measured in a vertical plane between the direction of the earth's magnetic field and the horizontal.

Paramagnetic bodies are those which tend to set the longest dimension parallel to the magnetic field, e.g., iron, cobalt, nickel.

Diamagnetic bodies tend to set the longest dimension across the magnetic field, e.g., bismuth.

Hysteresis.—The magnetization of a sample of iron or steel due to a magnetic field which is made to vary through a cycle of values, lags behind the field. This phenomenon is called hysteresis.

Current Electricity

Electric Current.—The rate of transfer of electricity. The transfer at the rate of one electrostatic unit of electricity in one second is the electrostatic unit of current. The electromagnetic unit of current is a current of such strength that one centimeter of the wire in which it flows is pushed sideways with a force of one dyne when the wire is at right angles to a magnetic field of unit intensity. The practical unit of current is the ampere, a transfer of one coulomb per second.

Conductivity.—A property of electric conductors depending on their dimensions, material and temperature which determines the current produced by a given electromotive force. The practical unit of conductivity is the mho, the reciprocal of the ohm.

Resistance.—The reciprocal of conductivity. The unit of resistance, the legal ohm is defined as the resistance to an unvarying current of a column of mercury at 0° C., 14.4521 grams in mass, of a constant cross-section, and 106.3 centimeters long. The cross-section is nearly one square millimeter.

Specific Resistance.—The resistance at 0° C. of a portion of substance of unit length and cross-section.

Temperature Resistance Coefficient.—The ratio of the change of resistance in a wire due to a change of temperature of 1° C. to its resistance at 0° C.

Induction.—Any change in the intensity or direction of a magnetic field causes an electromotive force in any conductor in the field. The induced electromotive force generates an induced current if the conductor forms a closed circuit.

Self-Induction.—The change in magnetic field due to the variation of a current in a conducting circuit causes an induced electromotive force in the circuit itself. This phenomenon is known as self-induction. It is measured as electromotive force produced in a conductor by unit rate of variation of the current through it. Units of self-induction are the centimeter (electro static) and the henry, which is equal to 10^9 centimeters of inductance.

Mutual Induction.—A change of current in a conductor is accompanied by a change of magnetic field which induces an electromotive force in a neighboring circuit. The mutual induction is measured by the electromotive force induced in one circuit by unit rate of variation of current in the other. Units, as of self-induction.

Light

Index of Refraction for any substance is the ratio of the velocity of light in a vacuum to its velocity in the substance. It is also the ratio of the sine of the angle of incidence to the sine of the angle of refraction. In general, the index of refraction for any substance varies with the wave length of the refracted light.

Minimum Deviation.—The deviation or change of direction of light passing through a prism is a minimum when the angle of incidence is equal to the angle of emergence.

Principal Focus of a lens or spherical mirror is the point of convergence of light coming from a source at an infinite distance.

Conjugate Foci.—Under proper conditions light divergent from a point on or near the axis of a lens or spherical mirror is focused at another point. The point of convergence and the position of the source are conjugate foci.

Spherical Aberration.—When large surfaces of spherical mirrors or lenses are used the light divergent from a point source cannot be exactly focused at a point. The phenomenon is known as spherical aberration.

Chromatic Aberration.—Due to the difference in the index of refraction for different wave lengths, light of various wave lengths from the same source cannot be focused in a point by a simple lens. This is called chromatic aberration.

Achromatic.—A term applied to lenses signifying their more or less complete correction for chromatic aberration.

Magnifying Power of an optical instrument is the ratio of the angle subtended by the image of the object seen through the instrument to the angle subtended by the object when seen by the unaided eye at a distance of 25 cms. (10 ins.)

Resolving Power of a telescope or microscope is indicated by the minimum separation of two objects for which they appear distinct and separate when viewed through the instrument.

Angular Aperture of an objective is the largest angular extent of wave surface which it can transmit.

Numerical Aperture is the sine of half the angular aperture, used as a measure of the optical power of the objective.

Dispersion.—The difference between the index of refraction of any substance for any two wave lengths is a measure of the dispersion for these wave lengths, called the coefficient of dispersion.

Diffraction.—If the light source were a point the shadow of any object would have its maximum sharpness; a certain amount of illumination, however, would be found within the geometrical shadow due to the diffraction of the light at the edge of the object.

Polarized Light.—Light which exhibits different properties in different directions at right angles to the line of propagation is said to be polarized. Specific rotation is the power of liquids to rotate the plane of polarization. It is stated in terms of specific rotation or the rotation in degrees per decimeter per unit density.

PHYSICAL FORMULÆ

Mechanics

Composition of Vectors.—If the angle between two vectors is A, and their magnitudes a and b, their sum,

$$c=\sqrt{a^2+b^2+2ab\cos A}.$$

Velocity.—If s is space passed over in time t, the velocity,

$$v=\frac{s}{t}.$$

Uniformly Accelerated Motion.—If v_0 is the initial velocity, v_t the velocity after time t, the acceleration,

$$a=\frac{v_t-v_0}{t}.$$

The velocity after time t,

$$v_t=v_0+at.$$

Space passed over in time t,

$$s=v_0t+\tfrac{1}{2}at^2.$$

Velocity after passing over space s,

$$v_s=\sqrt{v_0{}^2+2as}.$$

Space over in the nth second,

$$s=v_0+\tfrac{1}{2}a(2n-1).$$

Falling Bodies.—Symbols as for uniformly accelerated motion except that $v_0=0$ and g is the acceleration due to gravity. The above formulæ become,

$$v_t=gt,\quad s=\tfrac{1}{2}gt^2,\qquad v_s=\sqrt{2gs}.$$

Bodies Projected Vertically Upward.—If v is the velocity of projection, the time to reach greatest height,

$$t = \frac{v}{g}.$$

Greatest height,

$$h = \frac{v^2}{2g}.$$

Projectiles.—For bodies projected with velocity v at an angle α with the horizontal, the time to highest point of flight,

$$t = \frac{v \sin \alpha}{g}.$$

Total time of flight,

$$T = \frac{2v \sin \alpha}{g}.$$

Maximum height,

$$h = \frac{v^2 \sin^2 \alpha}{2g}.$$

Horizontal range,

$$R = \frac{v^2 \sin 2\alpha}{g}.$$

Angular Velocity.—If the angle described in time t is θ, the angular velocity,

$$\omega = \frac{\theta}{t}.$$

Angular Acceleration.—If the initial angular velocity is ω_0, and the velocity after time t is $= \omega_t$, the angular acceleration,

$$A = \frac{\omega_t - \omega_0}{t}.$$

The angular velocity after time t,

$$\omega_t = \omega_0 + At.$$

The angle swept out in time t,

$$\theta = \omega_0 t + \tfrac{1}{2} A t^2.$$

The angular velocity after movement through the arc θ,

$$\omega = \sqrt{\omega_0^2 + 2A\theta},$$

Momentum.—A mass m moving with velocity v has a momentum

$$M = mv.$$

Angular momentum of a mass whose moment of inertia is I, rotating with angular velocity ω, is

$$I\omega.$$

Force.—For a mass m and an acceleration a,

$$F = ma.$$

Moment of Force or Torque.—If a force F acts to produce rotation about a center at a distance d from the line in which the force acts, the force has a torque,

$$T = Fd.$$

Gravitation.—The force of attraction between two masses, m and m', separated by a distance r, k being the constant of gravitation,

$$F = k\frac{mm'}{r^2}.$$

(If m amd m' are given in grams, and r in centimeters, F will be in dynes if $k = 6.658 \times 10^{-8}$.)

Weight of mass m, where g is the acceleration due to gravity,

$$W = mg.$$

Acceleration Due to Gravity at any Latitude and Elevation. If ϕ is the latitude and H the elevation in centimeters the acceleration in C. G. S. units is,

$$g = 980.616 - 2.5928 \cos 2\phi + 0.0069 \cos^2 2\phi - 3.086 \times 10^{-6} H.$$

(Helmert's equation.)

Uniform Circular Motion.—If r is the radius of a circle, s the linear speed in the arc, ω the angular velocity and T the period or time of one revolution, the angular velocity is,

$$\omega = \frac{s}{r} = \frac{2\pi}{T}.$$

The acceleration toward the center is

$$a = \frac{s^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}.$$

The centrifugal force for a mass m,

$$F = \frac{ms^2}{r} = m\omega^2 r = \frac{4\pi^2 mr}{T^2}.$$

Application to the Solar System.—If M is the mass of the sun, G the constant of gravitation, P the period of the planet and r the distance of the planet from the sun, then the mass of the sun

$$M = \frac{4\pi^2 r^3}{GP^2} \quad (G = 6.657 \text{ for C. G. S. units.})$$

If P is the period and r the distance of a satellite revolving around the planet, the above expression for M gives the mass of the planet. The formula is written on the assumption that the orbit of the planet or satellite is circular, which is only approximately true.

Simple Harmonic Motion.—If r is the radius of the reference circle, ω the angular velocity of the point in the circle, θ the angular displacement at the time t after the particle passes the mid-point of its path, the linear displacement,

$$x = r \sin \theta = r \sin \omega t.$$

The velocity at the same instant,

$$v = r\omega \cos \theta = \omega\sqrt{r^2 - x^2}.$$

The acceleration,

$$a = -\omega^2 x.$$

The force for a mass m,

$$F = -m\omega^2 x = -\frac{4\pi^2 m x}{T^2}.$$

The period

$$T = 2\pi\sqrt{\frac{x}{a}}.$$

The Pendulum.—For a simple pendulum of length l, for a small amplitude, the period,

$$T = 2\pi\sqrt{\frac{l}{g}}, \quad \text{or} \quad g = 4\pi^2\frac{l}{T^2}.$$

For a sphere suspended by a wire of negligible mass where d is the distance from the knife edge to the center of the sphere whose radius is r, the length of the equivalent simple pendulum,

$$l = d + \frac{2r^2}{5d}.$$

If the period is P for an arc θ, the time of vibration in an infinitely small arc is approximately,

$$T = \frac{P}{1 + \frac{1}{4}\sin^2\frac{\theta}{4}}.$$

Foucault's Pendulum.—The rate of rotation in degrees per hour of a line on the surface of the earth relative to the plane of a Foucault's pendulum at latitude ϕ is,

$$\omega = 15 \sin \phi.$$

Work.—If a force F act through a space s, the work done is

$$W = Fs.$$

Power.—If an amount of work W is done in time t the power or rate of doing work is,

$$P = \frac{W}{t} = \frac{Fs}{t}.$$

Energy.—The potential energy of a mass m, raised through a distance h, where g is the acceleration due to gravity, is

$$PE = mgh.$$

The kinetic energy of mass m, moving with a velocity v, is

$$KE = \tfrac{1}{2}mv^2.$$

Simple Machines.—If a force P applied through a distance p results in a force F through a distance f, neglecting friction,

$$Pp = Ff.$$

Mechanical advantage in the case stated above is $\frac{f}{p}$.

If the force applied to overcome friction alone is x, the efficiency is,

$$E = \frac{Ff}{(P+x)p}.$$

Mass by Weighing on a Balance with Unequal Arms.—If W_1 is the value for one side, W_2 the value for the other, the true mass,

$$W = \sqrt{W_1 W_2}.$$

Sensitiveness of a Balance.—If w is the weight of the beam, h the distance of the center of gravity below the knife edge, a the length of the balance arms and x a small mass added to one pan, the deflection θ produced is given by

$$\tan\theta = \frac{a}{wh}x.$$

Elastic Coefficients

Young's modulus by stretching.—If an elongation s is produced by the weight of the mass m, in a wire of length l, and radius r, the modulus,

$$M = \frac{mgl}{\pi r^2 s}.$$

Young's modulus by bending, bar supported at both ends. If a flexure s is produced by the weight of mass m, added midway between the supports separated by a distance l, for a rectangular bar with vertical dimensions of cross-section a and horizontal dimension b, the modulus is,

$$M = \frac{mgl^3}{4sa^3b}.$$

For a cylindrical bar of radius r,

$$M = \frac{mgl^3}{12\pi r^4 s}.$$

For a bar supported at one end. In the case of a rectangular bar as described above,

$$M = \frac{4mgl^3}{sa^3b}.$$

For a round bar supported at one end,

$$M = \frac{4mgl^3}{3\pi r^4 s}.$$

Modulus of Rigidity.—If a couple $C(=mgx)$ produces a twist of θ radians in a bar of length l and radius r, the modulus is

$$M = \frac{2Cl}{\pi r^4 \theta}.$$

Coefficient of Restitution.—Two bodies moving in the same straight line with velocities v_1 and v_2 respectively, collide and after impact move with velocities v_3 and v_4. The coefficient of restitution is

$$C = \frac{v_4 - v_3}{v_2 - v_1}.$$

Viscosity.—Flow of liquids through a tube; where l is the length of the tube, r its radius, t the difference of pressure at the ends, η the coefficient of viscosity, the volume escaping per second,

$$v = \frac{\pi p r^4}{8l\eta} \qquad \text{(Poiseuille.)}$$

Rate of Fall of a Small Sphere in a Fluid.—Where V is the maximum velocity, r the radius of the sphere, M_s the mass of the sphere, M_l the mass of the same volume of liquid, g the acceleration due to gravity and η the coefficient of viscosity,

$$V = \frac{(M_s - M_l)g}{6\pi r\eta}.$$

Diffusion.—If the concentration (mass of solid per unit volume of solution) at one surface of a layer of liquid is d_1, and at the other surface d_2, the thickness of the layer h and the area under consideration A, then the mass of the substance which diffuses through the cross-section A in time t is,

$$m = KA\frac{(d_2 - d_1)}{h}t.$$

where K is the coefficient of diffusion.

Surface Tension.—The total force along a line of length l on the surface of a liquid whose surface tension is T,

$$F = lT.$$

Capillary Tubes.—If a liquid of density D rises a height h in a tube of internal radius r the surface tension is,

$$T = \frac{rhDg}{2}.$$

Pressure.—The pressure due to a force F distributed over an area A,

$$P = \frac{F}{A}.$$

Hydrostatic pressure on an area A at a distance h from the surface of a liquid of density D is,

$$F = PA \text{ (total pressure)} = AhDg.$$

Archimedes' Principle.—A body of volume V immersed in a liquid of density D is buoyed up by a force

$$F = DgV.$$

Velocity of Efflux of a Liquid.—If h is the distance from the opening to the free surface of the liquid, the velocity of efflux is

$$V = \sqrt{2gh}.$$

Diminution of Pressure at the Side of a Moving Stream.—If a fluid of density d moves with a velocity v the diminution of pressure due to the motion is (neglecting viscosity),

$$p = hdg = \tfrac{1}{2}dv^2.$$

Boyle's Law.—For a perfect gas, changing from pressure p and volume v to pressure p' and volume v' without change of temperature,

$$pv = p'v'.$$

Altitudes with the Barometer.—If b_1 and b_2 denote the corrected barometer readings at two stations, t the mean of the temperatures t_1 and t_2 of the air at the two stations, e_1 and e_2, the tension of water vapor at the two stations, h the mean height above sea level, ϕ the latitude, then the difference in elevation in centimeters is

$$H = 1{,}843{,}000(\log b_1 - \log b_2)(1 + 0.00367t)(1 + 0.0026 \cos 2\phi + 0.00002h + \tfrac{3}{8}k),$$

where $$k = \tfrac{1}{2}\left(\frac{e_1}{b_1} + \frac{e_2}{b_2}\right).$$

An approximate formula, sufficient for differences not over 1000 meters is

$$H = 1{,}600{,}000 \cdot \frac{b_1 - b_2}{b_1 + b_2}(1 + 0.004t).$$

Heat

Thermal Expansion.—If l_0 is the length at 0° C., α the the coefficient of linear expansion, the length at t° C. is,

$$l_t = l_0(1+\alpha t).$$

General Formula for Thermal Expansion.—The rate of thermal expansion varies with the temperature. The general equation giving the magnitude m_t (length or volume) at a temperature t, where m_0 is the magnitude at 0° C., is

$$m_t = m_0(1+\alpha t+\beta t^2+\gamma t^3 \ldots)$$

where α, β, γ, etc., are empirically determined coefficients.

Volume expansion. If V represents volume and β the coefficient of expansion,

$$V_t = V_0(1+\beta t).$$

For solids, $\beta = 3\alpha$ (approximately).

Expansion of Gases.—For an original volume V_0 at 0° C. the volume at t° C. (at constant pressure) is

$$V_t = V_0(1+0.00367t).$$

General Law for Gases:

$$p_t v_t = p_0 v_0\left(1+\frac{t}{273}\right).$$

Reduction of a Gas Volume to 0°C., 760 mm. Pressure.—If V is the original volume of a gas at temperature t and pressure p the volume at 0° C. and 760 mm. pressure will be,

$$V_0 = \frac{V}{(1+\alpha t)}\,\frac{H}{760}.$$

If d is the original density the density at 0° C. and 760 mm. pressure will be,

$$d_0 = d(1+\alpha t)\frac{760}{H},$$

$$\alpha = 0.00367 \text{ approximately.}$$

Gas Thermometer.—Where P_0, P_s, and P_x represent the total pressures with the bulb at 0° C., at the boiling-point of water and at the unknown temperature respectively, t_s the temperature of steam and t_x the unknown temperature,

$$t_x = t_s\frac{P_x - P_0}{P_s - P_0}$$

(approximately). The total pressure on the gas in the bulb is the sum of barometric pressure at the time and that measured by the manometer.

Specific Heat.—If a quantity of heat H calories is necessary to raise the temperature of m grams of a substance from t_1 to t_2° C., the specific heat,

$$s = \frac{H}{m(t_2 - t_1)}.$$

Specific Heat by the Method of Mixtures.—Where a mass m_1 of the substance is heated to a temperature t_1, then placed in a mass of water m_2 at a temperature t_2 contained in a calorimeter with stirrer (of same material) of mass m_3, specific heat of the calorimeter c, v the volume of the immersed portion of the thermometer, t_3 the final temperature, the specific heat of the substance,

$$s = \frac{(m_2 + m_3c + 0.46v)(t_3 - t_2)}{m_1(t_1 - t_3)}.$$

Black's Ice Calorimeter.—If a body of mass m and temperature t melts a mass m' of ice, its temperature being reduced to 0° C., the specific heat of the substance is,

$$s = \frac{80.1m'}{mt}.$$

Bunsen's Ice Calorimeter.—A body of mass m at temperature t causes a motion of the mercury column of l centimeters in a tube whose volume per unit length is v. The specific heat is

$$s = \frac{884lv}{mt}.$$

Conduction of Heat.—If the two opposite faces of a cube of a substance are maintained at temperatures t_1 and t_2, the heat conducted across the cube of section a and thickness d in a time T will be,

$$Q = K\frac{(t_2 - t_1)aT}{d}.$$

K is a constant depending on the nature of the substance, designated as the specific heat conductivity.

Wave Motion and Sound

Velocity of a Wave.—The velocity of propagation in terms of wave length λ and period T or frequency n is,

$$V = \frac{\lambda}{T} = n\lambda.$$

Velocity of a transverse wave in a stretched cord. If T is the tension of the cord and m the mass per unit length,

$$V = \sqrt{\frac{T}{m}}.$$

Velocity of Sound.—In terms of elasticity (bulk modulus) E and density d,

$$V=\sqrt{\frac{E}{d}}.$$

Frequency of Vibrating Strings.—For a string of length l, tension T, density d, and radius r, the frequency is,

$$n=\frac{1}{2rl}\sqrt{\frac{T}{\pi d}}.$$

Organ Pipes.—The frequency of vibration in a closed organ pipe of length l, where V is the velocity of sound in air, is

$$n=\frac{V}{4l}\text{ (fundamental.)}$$

In an open pipe,

$$n=\frac{V}{2l}\text{ (approximate.)}$$

Velocity of sound in air at a temperature t,

$$V=33{,}136+60.7t\text{ cm. per sec.}$$

Static Electricity

Force between Two Charges.—If two charges q and q' are at a distance r in a vacuum, the force between them is,

$$F=\frac{qq'}{r^2}.$$

Field Intensity, or force exerted on unit charge at a point distant r from a charge q in a vacuum,

$$H=\frac{q}{r^2}.$$

If the dielectric in the above cases is not a vacuum the dielectric constant K must be introduced. The formulæ become,

$$F=\frac{qq'}{Kr^2}. \qquad H=\frac{q}{Kr^2}.$$

The value of K is frequently considered unity for air. If the dielectric constant of a vacuum is considered unity the value for air at 0° C. and 760 mm. pressure is 1.000576.

Potential at a point due to a charge q at a distance r,

$$V=\frac{q}{Kr}.$$

Capacity in terms of charge and potential. A conductor charged with a quantity q to a potential V has a capacity,

$$C=\frac{q}{V}.$$

Capacity of a spherical conductor of radius r,

$$C=Kr.$$

Capacity of two concentric spheres of radii r and r',

$$C=K\frac{rr'}{r+r'}.$$

Capacity of a parallel plate condenser, the area of whose plates is A and the distance between them d,

$$C=\frac{KA}{4\pi d}.$$

Magnetism

Force between Two Magnetic Poles.—If two poles of strength m and m' are separated by a distance r in a medium whose permeability is μ (unity for a vacuum), the force between them is

$$F=\frac{mm'}{\mu r^2}.$$

The strength of a magnetic field at a point distant r from an isolated pole of strength m is,

$$H=\frac{m}{\mu r^2}.$$

Magnetic Moment.—If the poles are separated by a distance which is great compared with the dimensions of the magnet, the magnetic moment of a magnet of length l whose poles have values of $+m$ and $-m$ is,

$$M=ml.$$

Couple acting on a magnet of magnetic moment ml in a field of strength H. If the magnet is perpendicular to the direction of the field,

$$C=Hml=HM.$$

If the angle between the magnet and the field is θ,

$$C=Hml\sin\theta.$$

Action of One Magnet on Another.—The turning moment experienced by a magnet of pole strength m' and length $2l'$ placed at a distance r from another magnet of length $2l$ and pole strength m, where the center of the first magnet is on the axis (extended) of the second and the axis of the first is perpendicular to the axis of the second,

$$C = 8\frac{mm'll'}{r^3} = \frac{2MM'}{r^3}.$$

If the first magnet is deflected through an angle θ, the expression becomes,

$$C = \frac{2MM'}{r^3}\cos\theta.$$

Period of vibration of a magnet of magnetic moment M and moment of inertia I vibrating in a field of strength H,

$$T = 2\pi\sqrt{\frac{I}{MH}}.$$

Magnetic Induction.—If a substance of permeability μ is placed in a magnetic field H the magnetic induction in the substance,

$$B = \mu H.$$

If I is the magnetic moment for unit volume,

$$B = H + 4\pi I.$$

The susceptibility,

$$K = \frac{I}{H}, \qquad \mu = 1 + 4\pi K.$$

Tractive Force of a Magnet.—If a magnet with induction B has a pole face of area A the force is,

$$F = \frac{B^2A}{8\pi}.$$

If B and A are in C. G. S. units, A will be in dynes.

Current Electricity

Ohm's Law.—Current in terms of electromotive force E and resistance R,

$$i = \frac{E}{R}.$$

Current in a Simple Circuit.—The current in a circuit including an external resistance R and a cell of electromotive force E, and internal reistance r,

$$i = \frac{E}{R + r}.$$

For two cells in parallel,

$$i=\frac{E}{R+\frac{r}{2}}.$$

For two cells in series,

$$i=\frac{2E}{R+2r}.$$

Resistance of a conductor at 0° C., of length l, cross-section s and specific resistance ρ,

$$R_0=\rho\frac{l}{s}.$$

Resistance of a conductor at a temperature t whose resistance at 0° C. is R_0 and whose temperature resistance coefficient is α,

$$R_t=R_0(1+\alpha t).$$

Resistance of Conductors in Series and Parallel.—The total resistance of any number of resistances joined in series is the sum of the separate resistances. The total resistance of conductors in parallel whose separate resistances are r_1, r_2, r_3, . . . r_n is given by the formula

$$\frac{1}{R}=\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}\ .\ .\ .+\frac{1}{r_n}.$$

R is the total resistance.

For two terms this becomes,

$$R=\frac{r_1r_2}{r_1+r_2}.$$

Wheatstone's Bridge.—If the resistances r_1, r_2, r_3, and r_4 form the arms of a Wheatstone's bridge in order as the circuit (omitting cell and galvanometer connections) is traced, when the bridge is balanced,

$$\frac{r_1}{r_2}=\frac{r_4}{r_3}\quad\text{or}\quad\frac{r_1}{r_4}=\frac{r_2}{r_3}.$$

Heat Effect.—The heat in calories developed in a circuit by an electric current i flowing through a resistance r for a time t is,

$$H=\frac{ri^2t}{4.18}=\frac{Eit}{4.18}.$$

Electromagnetic Field.—The intensity of the magnetic field at the center of a circular conductor of radius r in which a current i flowing is,

$$H=\frac{2\pi i}{r}.$$

If the circular coil has n turns, the magnetic intensity at the center is,

$$H=\frac{2\pi ni}{r}.$$

Tangent Galvanometer.—A tangent galvanometer with n turns, of radius r, in the earth's field H, has a deflection θ. The current flowing is,

$$i=\frac{Hr}{2\pi n}\tan\theta.$$

If $\frac{2\pi n}{r}=G$ (the galvanometer constant),

$$i=\frac{H}{G}\tan\theta.$$

Electrolysis.—If a current i flows for a time t and deposits a metal whose electrochemical equivalent is e, the mass deposited is

$$m=eit.$$

Light

Spherical Mirrors.—If R is the radius of curvature, F principal focus, and f_1 and f_2 any two conjugate focal distances,

$$\frac{1}{f_1}+\frac{1}{f_2}=\frac{1}{F}=\frac{2}{R}.$$

Lenses.—For a single thin lens whose surfaces have radii of curvature r_1 and r_2, whose principal focus is F, the index of the fraction n and conjugate focal distances f_1 and f_2,

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}=(n-1)\left(\frac{1}{r_1}+\frac{1}{r_2}\right).$$

Radius of Curvature from Spherometer Readings.—If l is the mean length of the sides of the triangle formed by the points of the three legs, d the spherometer reading, the radius of curvature of the surface is

$$R=\frac{l^2}{6d}+\frac{d}{2}.$$

Index of Refraction.—If i is the angle of incidence, r the angle of refraction, v the velocity of light in the first medium, v' the velocity in the second medium, the index of refraction n,

$$n=\frac{\sin i}{\sin r}=\frac{v}{v'}.$$

For a prism of angle A where light passes at the angle of minimum deviation D, the index of refraction,

$$n=\frac{\sin\frac{1}{2}(A+D)}{\sin\frac{1}{2}A}.$$

Reflection of Light by a Transparent Medium in Air. (Fresnel's Formulæ).—If i is the angle of incidence, r the angle of refraction, n_1 the index of refraction for air (nearly equal to unity), n_2 index of refraction for a medium, then the ratio of the reflected light to the incident light is,

$$R=\frac{1}{2}\left[\frac{\sin^2\,(i-r)}{\sin^2\,(i+r)}+\frac{\tan^2\,(i-r)}{\tan^2\,(i+r)}\right].$$

If $i=0$ (normal incidence), and $n_1=1$ (approximate for air),

$$R=\left(\frac{n_2-1}{n_2+1}\right)^2.$$

Diffraction Grating.—If s is the distance between the rulings, d the angle of diffraction, then the wave length where the angle of incidence is 90° is (for the nth order spectrum),

$$\lambda=\frac{s\sin d}{n}.$$

If i is the angle of incidence, d the angle of diffraction, s the distance between the rulings, n the order of the spectrum, the wave length is,

$$\lambda=\frac{s}{n}(\sin i+\sin d).$$

Specific Rotation.—If there are n grams of active substance in v cubic centimeters of solution and the light passes through l centimeters, r being the observed rotation in degrees, the specific rotation (for 1 centimeter),

$$[\alpha]=\frac{rv}{nl}.$$

ACID PROOF WOOD STAIN

Solution No. 1	Solution No. 2
125 grams of copper sulphate	150 grams of good fresh anilin oil
125 grams of potassium chlorate	180 grams of concentrated hydrochloric acid
1000 grams of water	1000 grams of water

Wood must be free from paint, varnish, grease or chemicals. Apply two coats of solution No. 1 boiling hot with a paint brush, allowing each coat to dry thoroughly before the next coat is applied. Then apply two coats of solution No. 2 in the same way. When the wood is completely dried wash off excess chemicals with hot soapsuds. Finish with raw linseed oil. Polish comes from rubbing the oil down well with a cloth or sponge. Whenever the tables get dingy again go over them with a coat of linseed oil and rub smooth.

BLUE PRINT PAPER, Formula for Sensitizing

Solution A:	Water	50. c.c.,	8.5 oz.
	Iron and ammonium citrate	10. grams,	1.7 oz.
Solution B:	Water	50. c.c.,	8.5 oz.
	Potassium ferricyanide	8. grams,	1.4 oz.

Filter separately. The solutions, which may be preserved separately for some time, are best kept in the dark. For use, mix, in a dark room or by an artificial light of low intensity, equal quantities of the two solutions.

Any non-absorbent paper may be sensitized by brushing the solution over it rapidly with a soft, wide, flat brush, going over the surface twice, the second coat being applied in a direction at right angles to the first. An alternative method is to lower the paper, beginning at one edge, on to the surface of the solution in a tray and allow it to float for a few seconds. Care must be taken to exclude air bubbles. After sensitizing by either method, the paper should be hung by one edge in a dark room to dry.

CEMENTS

Glues of all kinds are useful for wood, leather, paper and glass, where the joints are not required to be waterproof.

For waterproof joints of nearly all substances, including metals, shellac may be used. Flakes of solid shellac may be used with heat or it may be used as a solution in alcohol.

Kotinsky cement, Chatterton's compound and other resinous cements are used for similar purposes and in the same way as solid shellac. Glass cells made up with compounds of this nature may be made impervious to alcohol by painting over the joints with a rubber cement made by melting up small pieces of rubber tubing and adding carbon disulphide to make a thin syrup.

For celluloid a cement made by dissolving celluloid shavings in acetone is recommended.

Brass fittings are usually cemented on glass tubing with sealing wax. The glass tube should be wound with thread or twine to secure a close fit. The glass and the brass fitting should be warmed slightly above the melting-point of wax. (Thick, or pressed glass should be warmed slowly.) Wax may be applied to both parts and the thread well saturated with the melted wax. Enough should be used to insure filling the space

completely. Join the parts while the wax is very soft and clamp in position until it is thoroughly cold.

For optical purposes, cementing glass, etc., Canada balsam is universally employed, and makes a permanent and nearly invisible joint.

CLEANING MERCURY

Mercury may be cleaned sufficiently for many laboratory purposes without distilling. Allow the mercury to fall in a fine spray into a quantity of dilute nitric acid, 25 parts of acid to 75 parts distilled water. After being passed through the acid one or more times it should be passed through distilled water and dried. Most of the water may be removed with a clean filter, and the mercury heated in a porcelain dish to about 110° C. To produce the spray the stem of a glass funnel may be drawn down so as to leave only a small opening for the escape of mercury or a glass tube with a capillary point attached to a funnel with a tightly fitting rubber tube.

A three- to four-foot length of one-inch glass tube closed at one end and supported in a vertical position may be used to contain the acid solution. If a small glass tube be fused into the lower closed end of the large tube, and bent so as to stand up for a distance a little greater than 1/13.6, the column of acid solution in the large tube, a U-tube is formed in which a short column of mercury supports the long column of acid solution.

The end of the small tube should be bent over at the top so as to facilitate the delivery of the mercury and a short piece of clean rubber tubing with a pinch-cock put on at the start; as soon as mercury enough has collected in the bottom of the tube the pinch-cock may be opened. The mercury will rise nearly or quite to the top of the small tube, and as the quantity increases will be delivered from the small tube as fast as it falls in the spray.

The reversed end of the small tube should be short to avoid forming a siphon, which would completely empty the apparatus.

An efficient procedure, especially if the mercury is greasy, consists in spraying the mercury by means of the above apparatus, first, through a dilute solution (10%) of potassium hydroxide, then through dilute nitric acid (10–15%) and finally through distilled water.

CLEANING OPTICAL SURFACES FOR SILVERING

(From Miller's Laboratory Physics, Ginn & Co., publishers, by permission.)

Probably the most important part of the silvering process is the proper cleaning of the surface to be silvered.

The surface is thoroughly cleaned of grease or other organic matter by the usual methods, using alcohol or chromic acid. Then it should be carefully cleaned with strong nitric acid, the whole surface being firmly rubbed with pure cotton tied to a rod of wood or glass. Care should be taken not to injure the surface. Rinse with water, and then wash the surface thoroughly with a strong solution of caustic potash, rubbing with a

cotton brush as before. Finally, rinse with distilled water, and keep the surface wet until it is placed in the silvering solution. If the distilled water wets the whole surface uniformly the cleaning may be sufficient; if it does not wet uniformly, the operations must be repeated. The fingers should not touch the edges of the glass during the latter cleaning operations, as a layer of organic matter is apt to spread over the surface and render the silvering uneven.

Dr. Brashear recommends that the surface, after the washings described above, be rubbed with prepared chalk on a cotton wad until it is thoroughly dry and clean. It may then be put into the silvering solution at one's convenience.

COLORED LIQUIDS

For rendering columns of water easily visible, add a few drops of one per cent alcoholic solution of fluorescein to a liter of water. The dilute solution of fluorescein is bright green by reason of its fluorescence, although colorless by transmitted light.

A small quantity of an aqueous (1%) solution of uranine (the sodium salt of fluorescein) may be used in place of the alcoholic solution mentioned above.

If solutions showing color by transmission are desired, dilute aqueous may be made with any of the following dyes:

Dye	Color
Erythrosine	Pink
Eosine	Pink (green fluorescence)
Rhodamine B	Pink (red fluorescence)
Ponceau 2R	Scarlet
Naphthol green	Green
Methylene green	Bluish green
Methylene blue	Blue
Methyl violet	Purple

CROSS HAIRS

The spider lines which serve as an index in reading telescopes may be quickly replaced in an emergency by single silk fibers (from ordinary sewing silk) attached by soft wax. Single fibers may easily be removed from an untwisted strand.

Spider web should be used in permanent work. The fibers of the egg nest of certain species are employed and may be obtained of most dealers in scientific apparatus. In mounting them the following suggestions may be useful: The cross hair diaphragm of the telescope should be removed and clamped in a horizontal position. A bow of brass wire, about No. 28, should be employed to stretch the fiber. A background of black velvet makes the fibers more easily visible. With soft wax or other convenient adhesive ready on both tips of the bow, a fiber of the required length is to be disentangled with tweezers and wrapped several times about the ends of the bow under tension sufficient to straighten the fiber. The fiber, now con-

veniently handled by the wire bow, should be cautiously lowered onto the diaphragm in the proper position, the wire left hanging.

A small drop of shellac varnish applied at each side will hold the fiber in position as soon as it is thoroughly dry, after which the ends of the fiber should be cut away.

FLUORESCENT SCREENS

For observations of the ultra-violet spectrum, moisten a small quantity of anthracene with water and brush a thin layer over a ground-glass surface. On drying most of the anthracene will adhere to the glass. The prepared surface should be placed so as to receive the radiation directly, glass being comparatively opaque to the shorter wave lengths.

GLASS-GRINDING FLUID

Turpentine	45	c.cm.
Ether (ethyl oxide)	22.5	c.cm.
Camphor gum	31	grams

To be used with powdered emery for grinding glass.

For smoothing edges a sheet of emery cloth moistened with the above solution may be used.

Plane surfaces should be ground on thick plate glass.

For grinding glass stoppers use coarse emery, turn in one direction, finish with fine emery.

LABELS FOR BOTTLES

Ordinary gummed labels written upon, preferably, with India ink, may be protected after being gummed to the bottle by a coat of lacquer or varnish. A more complete protection is obtained by painting the label, after it is in place, with melted paraffin.

MIRRORS FOR SPECTROMETER ADJUSTMENT

A small square of thick plate glass with edges ground smooth and silvered on one surface affords a means of accurate adjustment.

To avoid the necessity of frequently resilvering, which arises where the mirrors are in constant use, the following course is suggested:

From selected German plate mirror 2 to 3 mm. thick, cut two pieces of the same size, say 4×5 cm. Remove the protective layer of varnish or paint from both pieces by soaking in alcohol and rubbing with cotton, being careful not to injure the silver surface. From one piece remove every trace of varnish by repeated rinsing, dry and polish the silver surface thus exposed by stroking lightly with a chamois rouge pad. From the other piece remove the silver by nitric acid, wash thoroughly in distilled water and dry. Cement the clear piece on the silver face of the other with Canada balsam. This is accomplished by placing two or three drops of Canada balsam in xylol (obtained in collapsible tubes) on the center of the silver face, and

evenly lowering upon it the clear glass. The balsam should spread rapidly to the edges of the plates. Minute bubbles of air in the balsam film are harmless; if large bubbles are present the plates should be slipped apart, cleaned with alcohol and the process repeated.

The balsam will be sufficiently hard in a few days to allow the excess to be scraped from the edges and the plates bound together with lantern slide binding strip. Gentle heat may be used to harden the balsam more rapidly.

POLARITY TEST PAPER

Dissolve one gram of phenolphthalein in a small quantity of alcohol. Add the solution of phenolphthalein to 100 c.cm. of a 10 per cent solution of potassium chloride in distilled water. Filter paper should be soaked in the solution and dried. A strip of paper moistened with water and placed in contact with the two terminals will show a bright red stain at the negative terminal.

SILVERING GLASS

Brashear's Process

(From Miller's Laboratory Physics, Ginn & Co., publishers, by permission.)

Two solutions are required, one, the reducing solution, should be prepared at least a week before it is used, and it may be made in large quantity and kept in stock with advantage; the other solution is to be prepared when used.

Reducing Solution

Distilled water	700 c.cm.
Pure sugar (loaf, granulated or rock candy)	80 g.

When dissolved add

Alcohol	175 c.cm.
Strong nitric acid (sp. gr. 1.42)	3 c.cm.
Add water to make	1000 c.cm.

For silvering, the mirror may rest face up on the bottom of a suitable dish; it may stand on edge, or be supported in any manner, face downward, dipping into the upper part of the solution. In the latter case, the mirror may be fastened with wax to a stick laid across the dish, or it may be supported on glass feet or on paraffined wood wedges. Dr. Brashear recommends that the mirror, if round, form the bottom of the silvering dish, which is completed by wrapping a strip of paraffined paper around the edge of the mirror, this being held in place by rubber bands or fastened with several wrappings of cord.

Having selected a dish and support for the mirror, measure with water the quantity of solution that will be required to make a layer a centimeter or two thick over the surface to be silvered. For each 150 c.cm. of final solution, 1 g. of silver nitrate and 0.5 g. of caustic potash (purified by alcohol) will be required. Dissolve the silver and potash separately, using quantities of water of the proportion of 100 c.cm. to 1 g.

of the solid. Ordinary graduates or flasks are the most convenient form of vessel in which to mix the solutions. Into the silver nitrate solution pour a few drops of dilute aqua ammonia. The solution will turn to a dark brown color; add ammonia little by little till the precipitate is nearly but not quite redissolved. Now add the potash solution, when a precipitate will again be formed. This is to be nearly, but not entirely, redissolved by the addition of more ammonia, a few drops being sufficient this time. After the ammonia has been added shake or stir the solution well and wait a minute or two to be certain that it does not entirely clear. If by chance too much ammonia has been used, a little silver nitrate is to be dissolved and added, a few drops at a time, till a permanent precipitate is formed. This excess of silver must be present, the solution showing a decided brown tint. The solution may be filtered, though usually this is not necessary.

A quantity of reducing solution equal to about a twenty-fifth part of the solution just prepared is measured out. The mirror, having been properly cleaned and rinsed with distilled water, is placed in position. The reducing solution is poured into the silver and potash solution, and mixed by a quick shaking of the graduate or stirring with a glass rod; the whole is then poured into the dish. If the mirror is immersed face down, care is necessary to remove air bubbles; the mirror may well be immersed after the solution is in, being dipped in at one side first. If the mirror is at the bottom of the dish, after cleaning it is covered with a thin layer of water, and the prepared solutions are poured into the dish without further trouble. In the latter case the dish must be rocked during the time of deposition.

The solution soon turns to a black color, which in a few minutes will turn to a brown; and when it becomes a light gray and the precipitate is flocculent, which may be in ten or fifteen minutes, the operation is at an end. If the mirror is allowed to remain in the solution too long, the surface will have a bleached appearance, which polishing will hardly remove. Remove the mirror, rinse with water, and carefully wipe off the sediment with a tuft of absorbent cotton. It is then set on edge to dry; a rinsing with alcohol will facilitate the drying, or all water may be safely taken up by pressing clean blotting paper over the surface.

When dry, the surface may be polished, if necessary, with a small pad of chamois leather stuffed with cotton, on which is spread a little rouge. Small, circular strokes of the pad, with light pressure, will soon bring out the deep luster of the silver.

A uniform temperature of the bath and the glass, of about 20° is essential to success.

Since fulminating silver is liable to be produced by the action of ammonia on silver oxide, especially in a warm room, all solutions should be thrown away as soon as the silvering operation is completed. The used solutions may be poured into a large jar, in which is thrown some common salt; this causes the silver to be precipitated as the chloride, and about 90 per cent of the original silver may be recovered.

Rochelle Salts Process

(From Miller's Laboratory Physics, Ginn & Co., publishers, by permission.)

For depositing the uniform thin film of silver required on the half-silvered glass of the interferometer, the following method is more suitable than the one described above, as the silver is deposited more slowly. If a thick film is desired, two or more successive deposits may be made, each of which may require an hour's time.

Dissolve 5 g. of silver nitrate in 300 c.cm. of distilled water, and add dilute aqua ammonia until the precipitate formed is nearly, *but not entirely*, redissolved in the manner explained in the preceding method. Filter the solution and add water to make 500 c.cm.

Dissolve one g. of silver nitrate in a small quantity of water and pour into about half a liter of boiling water; dissolve 0.83 g. of Rochelle salts in a small quantity of water, and add to the boiling solution. Continue the boiling for half an hour, till the gray precipitate collects as a powder in the bottom of the flask. Filter hot, and add water to make 500 c.cm.

These solutions may be kept in the dark for a month or two.

For silvering, equal volumes of the two solutions are mixed, and the glass is supported in the mixture in whatever fashion is convenient. Various methods are mentioned in the preceding article. The thickest possible deposit may require an hour's time. A second deposit may be made upon the first if necessary to secure the desired thickness. The drying and polishing may be carried out as described above.

A half-silvered film will be produced in about a minute; only experience can determine when the proper thickness has been secured. The glass appears as though it were very lightly smoked. A film that reflects a little more than half the light incident at 45° is desirable for interferometer use. A simple method of testing is to look at two similar gas flames, one seen through the film and the other seen reflected by it. It is well to silver at once all four surfaces of the two plane-parallel plates of the interferometer and to select for use that film which is of the proper and most uniform thickness.

SOAP SOLUTION FOR SOAP FILM EXPERIMENTS

Pure castile or palm-oil soap..........	1 oz.
Distilled water......................	8 oz.
Pure glycerine.......................	4 oz.

Cut the soap in thin shavings and dissolve in the water. When the solution is complete, add the glycerine and mix very thoroughly. On standing the liquid becomes clear at the bottom. The clear portion may conveniently be removed by a siphon and preserved indefinitely.

SODIUM LIGHT

Paper is to be soaked in a saturated solution of common salt, borax or other salt of sodium, and dried. When wrapped around a Bunsen burner, secured by a twist of wire and pushed up into the edge of the flame, a sodium flame of considerable intensity is obtained. As the ash of the paper breaks away it must be occasionally raised. Lithium chloride may be used in place of or with sodium salt to give the lithium line for spectrometric measurement. Sheet asbestos (thin) may replace the paper if convenient.

SOLDERS

Composition by weight.						Temperature of fusion.	Metals for which it is used.	Flux commonly used.
Lead.	Tin	Copper.	Zinc.	Silver.	Gold.			
1	1	...	...	..	...	188° C.	Lead	Tallow
3	5	...	...	..	...	176	Zinc	Zinc chloride with 25% HCl
2	5	...	...	..	...	170	Copper brass	Zinc chloride (neutral) or resin
							Iron	Zinc chloride or ammonium chloride
		2	1	..	...	......	Iron or copper	Borax
		55	45	..	...	880	Iron, copper or brass	Borax
		4.5	0.5	15.0	...	1005	Iron, copper or gold	Borax
		6.5	2.0	11.0	...	983	Iron, copper or gold	Borax
		4	...	6	10	......	Gold	

STOPCOCK GREASE

Vaseline........................	16 parts
Pure gum rubber................	8 parts
Paraffin........................	1 part

Melt all together. More paraffin may be added if the compound is not stiff enough.

UNIVERSAL WAX

(1) A soft wax useful in the laboratory may be made by melting together paraffin, vaseline and paraffin oil in various proportions according to the pliability desired.

(2) Another authority recommends equal quantities of beeswax and turpentine (by weight). It is customary to color the wax by adding finely-powdered Venetian red.

(3) Melt together 1 part of Venice turpentine and 5 parts of beeswax. Color with vermilion.

PHOTOGRAPHIC FORMULÆ

DEVELOPERS FOR PLATES OR FILMS

Pyro

A.	Pure Water	16 ounces
	Oxalic Acid	12 grains
	Pyrogallic Acid	1 ounce
B.	Pure Water	16 ounces
	Dry Sulphite of Soda	2 ounces
	If negatives are too yellow use more sulphite.	
C.	Pure Water	16 ounces
	Dry Carbonate of Soda	1 ounce

Mix for immediate use

A	1 ounce
B	1 ounce
C	1 ounce
Water (65° to 70° F)	10 ounces

Factor 12

Metol-Hydrochinon

A.	Pure Water	64 ounces
	Metol	120 grains
	Hydrochinon	120 grains
	Dry Sulphite of Soda	2 ounces
B.	Pure Water	16 ounces
	Dry Carbonate of Soda	2 ounces

Use

A	4 ounces
B	1 ounce
Pure Water	4 ounces

Factor 15

Dissolve in the order given. Metol should always be dissolved in water before the Sulphite is added, or before it is mixed with Sulphite solution, otherwise it may precipitate.

DEVELOPERS FOR TRANSPARENCIES

(*Lantern Slides*)

Hydrochinon

Pure Water	20 ounces
Hydrochinon	60 grains
Dry Sulphite of Soda	120 grains
Bromide of Potassium	6 grains
Citric Acid	6 grains
Dry Carbonate of Soda	1 ounce

Use full strength.

PHOTOGRAPHIC FORMULÆ (Continued)

DEVELOPER

(For Line Work)

EDINOL

Pure Water	30 ounces
Dry Sulphite of Soda	2 ounces
Edinol	150 grains
Bromide of Potassium	100 grains
Carbonate of Potassium	2½ ounces

Use full strength.

This developer, with contrast plates, produces negatives of great intensity and absolute clearness, desirable for copies of pencil sketches, pen drawings, line work, etc.

DEVELOPING FORMULA FOR EXTREME CONTRAST

HYDROCHINON

A.	Water	32 ounces
	Hydrochinon	1½ ounces
	Sodium Sulphite (dry)	1 ounce
	Sulphuric Acid	60 minims
B.	Water	32 ounces
	Sodium Carbonate (dry)	1 ounce
	Potassium Carbonate	3 ounces
	Potassium Bromide	120 grains
	Sodium Sulphite (dry)	3 ounces

To develop take equal parts A and B.

FORMULÆ FOR TANK DEVELOPMENT

15-MINUTE DEVELOPMENT AT A TEMPERATURE OF FROM 65° TO 70° F. OR 18° C.

PYRO

Sodium Sulphite (dry)	115 grains
Sodium Carbonate (dry)	90 grains
Pyro	45 grains
Water	48 ounces

Dissolve immediately before use. Use full strength.

The following formulæ are for 20-minute development at 65° F. or 18° C.

GLYCIN-STOCK SOLUTION

Glycin	120 grains
Sulphite of Soda, dried (Anhydrous)	360 grains
Carbonate of Soda, dried (Anhydrous)	360 grains
Water	35 ounces

To each part of stock solution, add three parts water.

PHOTOGRAPHIC FORMULÆ (Continued)

Formulæ for Tank Development (Continued)

Edinol-stock Solution

Edinol	145 grains
Sulphite of Soda, dried (Anhydrous)	300 grains
Carbonate of Soda, dried (Anhydrous)	300 grains
Water	40 ounces

To each part of stock solution, add three parts water.

Hydrochinon-stock Solution

Hydrochinon	90 grains
Sodium Sulphite, dried (Anhydrous)	400 grains
Sodium Carbonate, dried (Anhydrous)	390 grains
Water	30 ounces

To each part of stock solution add three parts water.

FIXING BATHS FOR PLATES OR FILMS

Acid Fixing and Hardening Bath

A.	Water (1 gallon)	128 ounces
	Hyposulphite of soda	32 ounces
B.	Water	32 ounces
	Dry Sulphite of soda	3 ounces
	Sulphuric Acid C. P.	½ ounce
	Powdered Chrome Alum	2 ounces

Note: — Be sure to mix solution B exactly in given proportions and rotation.

Always pour B into A while stirring well. If this is not done precipitation will take place.

During the cold season one half the quantity of Solution B is sufficient for full quantity of Solution A.

This bath remains clear after frequent use, does not discolor the negatives and hardens the film to such a degree that the negatives can be washed in warm water and dried by artificial heat if necessary. They should be left in the bath ten to twenty minutes after the bromide of silver appears to have been dissolved, to insure permanency, freedom from stain and perfect hardening.

If the bath becomes exhausted by continued use, replace it by a new one.

It is not advisable to use this bath, which contains sulphuric acid, in metal developing tanks.

PLAIN FIXING BATH

Water	32 ounces
Hyposulphite of soda	8 ounces

Do not use the bath when it is discolored; it must be made fresh each day.

PHOTOGRAPHIC FORMULÆ (Continued)

INTENSIFICATION

Prepare the following solution, which will keep and work well until exhausted.

No. 1. 16 ounces of Water.
120 grains of Bichloride of Mercury.
120 grains of Bromide of Potassium.

No. 2. Number 2 should be mixed fresh.
8 ounces of Water.
1 ounce of Dry Sulphite of Soda.

After the negative is well fixed and washed, immerse in No. 1 until it has become thoroughly whitened, and after rinsing carefully place it in No. 2, leaving it there until entirely cleared. In case sufficient intensification has not been gained, wash for ten minutes, repeat the operation and finally wash well. If after intensification the negative is too dense it may be reduced by placing it for a few seconds in water 16 ozs., Hypo. 1 oz.

If the negative has not been thoroughly fixed and washed before intensification, stains will ensue.

REDUCTION

A.	Water	16 ounces
	Hyposulphite of Soda	1 ounce
B.	Water	16 ounces
	Potassium Ferricyanide	1 ounce

As this solution is affected by light, the bottle containing it should be of amber color or wrapped in opaque paper and kept in the dark when not in use.

Mix for immediate use: —

A	8 ounces
B	1 ounce

Use in subdued daylight.

The negative can be placed in this solution directly after fixing. If a dry negative is to be reduced, it must be soaked in water for at least half an hour before applying the solution. To avoid streaks, always rinse the negative before holding it up for examination. As soon as sufficiently reduced wash thoroughly.

IRON CLEARING SOLUTION

To remove yellow stain caused by Pyro or Hydrochinon developer, wash well to free from hypo and place in

Water	20 ounces
Ferrous Sulphate, pure	3 ounces
Sulphuric Acid C. P	1 ounce
Powdered Alum	1 ounce

until stain is gone, then wash well.

PHOTOGRAPHIC FORMULÆ (Continued)

DEVELOPERS FOR GASLIGHT PAPER

Hydro-Metol

Water	16 ounces
Metol	18 grains
Hydrochinon	18 grains
Sodium Sulphite, dry	204 grains
Sodium Carbonate, dry	408 grains
Bromide of Potassium	10 grains

If the whites fail to develop without fog 10% potassium bromide solution may be added, a few drops at a time, until the desired results are obtained.

Hydrochinon

Water	10 ounces
Sodium Sulphite, dry	67 grains
Hydrochinon	34 grains
Sodium Carbonate, dry	510 grains
Saturated Solution of Potassium Bromide	3 drops

This formula may be substituted for the hydro-metol formula given above if it is impossible to obtain metol.

Fixing Bath

Water	64 ounces
Hypo	16 ounces

Dissolve, then add the following acid hardener:

Water	5 ounces
Sodium Sulphite (dried powd.)	½ ounce
Acetic Acid 25%	3 ounces
Alum (powdered)	½ ounce.

This fixing bath is also excellent for dry plates and films, and will keep indefinitely before using; therefore it can be made up some time in advance. One pint of the bath should fix at least fifty 4 x 5 prints. The acid fixing bath can be used repeatedly. It keeps with but little care. It will by degrees become alkaline by the gradual addition of developer adhering to the prints. It should be discarded entirely when it becomes frothy, and a fresh bath prepared.

DIAPHRAGM NUMBERS

U. S.	1	equals	F/4
"	4	"	F/8
"	8	"	F/11
"	16	"	F/16
"	32	"	F/22
"	64	"	F/32
"	128	"	F/45
"	256	"	F/64

MEASURES AND UNITS

WEIGHTS AND MEASURES

U. S. System

LENGTH

Inches.	Feet.	Yards.	Rods.	Miles.
12	1	....	....	....
36	3	1	....	....
198	$16\frac{1}{2}$	$5\frac{1}{2}$	1	....
....	5280	1760	320	1

1 fathom = 6 feet
1 furlong = 40 rods = 660 feet
1 knot or nautical mile = 1.15 statute miles = 1′ of arc on the earth's surface at the equator
1 surveyor's chain = 66 feet = 100 links (each link = 7.92 inches)
1 engineer's chain = 100 feet = 100 links
1 mil = .001 inch

AREA

Square inches.	Square feet.	Square yards.	Square rods.	Acres.
144	1	....	....	....
1296	9	1	....	....
....	$272\frac{1}{4}$	$30\frac{1}{4}$	1	....
....	43560	4840	160	1

1 square mile = 640 acres
1 acre = 10 square chains (surveyor's)
1 sq. mil = .000001 sq.in.
1 circular mil = .000000785 sq.in. (area of a circle whose diameter is one mil)

VOLUME

1728 cubic inches = 1 cubic foot
27 cubic feet = 1 cubic yard

WEIGHTS AND MEASURES (Continued)

U. S. System (Continued)

Liquid Measure

Gills.	Pints.	Quarts.	Gallons.	Cubic inches.
4	1	....	....	28.38
8	2	1	....	57.75
32	8	4	1	231.

1 hogshead = 63 gallons
1 tun = 252 gallons
1 British imperial gallon = 277.3 cu.in. = 1.2 U. S. gallons

Apothecaries' Fluid Measure

Minims.	Fluid drams.	Fluid ounces.	Pints.	Gallons.
60	1	....	....	....
480	8	1	....	....
7680	128	16	1	....
....	....	128	8	1

Dry Measure

Pints.	Quarts.	Pecks.	Bushels.	Cubic inches.
2	1	....	....	67.2
16	8	1	....	537.6
	32	4	1	2150.4

1 British imperial bushel = 2218.2 cu.in. = 1.03 U. S. bushels
1 cord = 128 cu.ft.

Mass

Note.—Three systems are in use—avoirdupois, troy and apothecaries'. The grain is the same in all.

Avoirdupois—Commercial

Grains.	Drams.	Ounces.	Pounds.	Tons.
27.34	1		....	....
437.5	16	1	....	....
7000.	256	16	1	....
....	....	....	2000	1

1 long ton = 2240 lbs. = 20 hundred weight (long)
1 hundred weight (short measure) = 100 lbs.
1 pound avoirdupois = the mass of 27.70 cu.in. of water weighed in air at 35.85° F. barometer pressure 30 of mercury

WEIGHTS AND MEASURES (Continued)

U. S. System (Continued)

Troy Weight

Grains.	Pennyweight.	Ounces.	Pounds.
24	1	....	....
480	20	1	....
5760	240	12	1

1 pound troy = .823 pound avoirdupois
1 carat = 3.2 grains

Apothecaries' Weight

The grain, ounce and pound are the same as in troy weight.

Grains.	Scruples.	Drams.	Ounces.	Pounds.
20	1	....	....	....
60	3	1	....	....
480	24	8	1	....
5760	288	96	12	1

Time

Seconds.	Minutes.	Hours.	Days.	Years.
60	1	....	....	....
3600	60	1		....
86400	2040	24	1	....
....	....	....	365.24	1 (common)
....	....	....	365.256	1 (sidereal)

Angle

Seconds.	Minutes.	Degrees.	Circumference.
60	1	....	....
3600	60	1	....
....	....	360	1

1 radian $=57.^\circ 2958=206265''$
2π radians = 1 circumference.

WEIGHTS AND MEASURES (Continued)

Metric System

Length

1 millimeter	=	.001	meter
1 centimeter	=	.01	meter
1 decimeter	=	.1	meter
1 meter			
1 dekameter	=	10.	meters
1 hektometer	=	100.	meters
1 kilometer	=	1000.	meters
1 myriameter	=	10000.	meters
1 micron	=	.001 mm. (symbol μ)	
1 ångström unit	=	.0000001 mm.	
1 micromillimeter	=	.000001 mm.	

Area

1 square millimeter	=	.0000001 square meter
1 square centimeter	=	.00001 square meter
1 square decimeter	=	.001 square meter
1 centare	=	1 square meter
1 are	=	100 square meters
1 hectare	=	10,000 square meters

Volume and Capacity

1 milliliter	=	.001 liter	= 1 cubic centimeter
1 centiliter	=	.01 liter	
1 deciliter	=	.1 liter	
1 liter	=	1 cubic decimeter, 1000 cubic centimeters	
1 dekaliter	=	10 liters	
1 hektoliter	=	100 liters	
1 kiloliter	=	1000 liters	= 1 cubic meter = 1,000,000 cu.cm.

Mass

1 milligram	=	.001	gram
1 centigram	=	.01	gram
1 decigram	=	.1	gram
1 gram			
1 dekagram	=	10	grams
1 hektogram	=	100	grams
1 kilogram	=	1000	grams
1 myriagram	=	10000	grams
1 quintol	=	100000	grams
1 millier or tonneau	=	1000000	grams

1 cubic centimeter of water at ordinary temperature weighs about 1 gram

MISCELLANEOUS REDUCTION FACTORS

π radians = 180 degrees
1 degree = 0.017453 radian
1 radian = 57°.2958 = 3437′.75 = 206265″.
1 sidereal second = 0.99727 mean solar second
1 pound per cubic foot = .01602 gram per cubic centimeter
1 foot per second per second = 30.4796 cm. per second per second
1 poundal = 13825 dynes
76 cm. of mercury at 0° C. (g. = 980) = 1.012630 dynes per sq.cm. or 14.697 pounds per sq.in.
1 foot-pound (g. = 980) = 13.55×10^6 ergs
1 foot-poundal = 421.390 ergs
1 horse power (g. = 980) = 745.2 watts
1 mean calorie = 4.184×10^7 ergs (mechanical equivalent of heat)
1 B.T.U. = 251.99 calories.
1 calorie = 0.003968 B.T.U.
1 B.T.U. per pound = 0.5556 calorie per gram
1 calorie per gram = 1.800 B.T.U. per pound

RELATIONS OF ELECTRICAL UNITS

1 ohm = 10^9 electromagnetic units = $1/9 \times 10^{-11}$ electrostatic units,
1 volt = 10^8 electromagnetic units = $1/3 \times 10^{-2}$ electrostatic units
1 ampere = 10^{-1} electromagnetic units = 3×10^9 electrostatic units
1 coulomb = 10^{-1} electromagnetic units = 3×10^9 electrostatic units
1 farad = 10^{-9} electromagnetic units = 9×10^{11} electrostatic units
1 farad = 1,000,000 microfarads.

VALUE OF THE GAS CONSTANT R FOR VARIOUS UNITS

Units of pressure.	Units of volume.	R per gram molecule.
Atmospheres	Volume at 0° C.	0.003662
Atmospheres	c.cm.	82.07
Atmospheres	liters	0.08207
Atmospheres	cubic meters	
Dynes per sq.cm. (barye)	c.cm.	8.3156×10^7
Kilograms per sq.m. (g. = 980.6)	c.cm.	8.48×10^5
		R per lb. molecule.
Pounds per sq.in.	cu.in.	18510.
Pounds per sq.in.	cu.ft.	10.71
Atmospheres	cu.in.	1260.
Atmospheres	cu.ft.	0.729

FACTORS FOR CONVERSION OF ENERGY UNITS

(From Perkins' Introduction to General Thermodynamics, John Wiley & Sons, publishers, by permission.)

	Gram-Calories.	B.T.U.	Joules.	Foot-pounds.	Kilogm.-meters.	Liter-atmos.	Cu.ft.-atmos.	Foot-Poundals	Horse-power Hours.
Gram-calorie...	1.	3.968×10^{-3}	4.185	3.087	.4267	4.130×10^{-2}	1.459×10^{-3}	99.31	1.5591×10^{-6}
B.T.U.........	252.	1	1055.	777.9	107.5	10.41	.3676	25030.	3.929×10^{-4}
Joule..........	.2389	9.482×10^{-4}	1.	.73756	.1019	9.689×10^{-3}	3.485×10^{-4}	23.73	3.725×10^{-7}
Foot-pound....	.3240	1.286×10^{-3}	1.356	1.	.113826	1.3381×10^{-2}	4.7253×10^{-4}	32.174	5.0505×10^{-7}
Kilogr.-meter ..	2.343	9.298×10^{-3}	9.806	7.2327	1.	9.678×10^{-2}	3.4177×10^{-3}	232.7	3.6529×10^{-6}
Liter-atmos....	24.21	9.607×10^{-2}	101.32	74.733	10.333	1.	3.5319×10^{-2}	2403.8	3.7734×10^{-5}

CONVERSION OF PRESSURE UNITS

(From Perkins' Introduction to General Thermodynamics, John Wiley & Sons, publishers, by permission.)

	Dynes per sq.cm.	Grams per sq.cm.	Kilo. per sq. meter.	Mm. of Mercury.	Atmospheres.	Lbs. per sq.in.	Lbs. per sq.ft.
Dynes per sq. centimeter..	1.	1.0198×10^{-3}	1.0198×10^{-2}	7.5010×10^{-4}	9.8697×10^{-7}	1.4504×10^{-5}	2.0887×10^{-3}
Gram per sq. centimeter...	980.6	1	10	7.3551×10^{-1}	9.6777×10^{-4}	1.4223×10^{-2}	2.0481
Kilogram per sq. meter....	98.06	10^{-1}	1	7.3551×10^{-2}	9.6777×10^{-5}	1.4223×10^{-3}	2.0481×10^{-1}
Millimeter of mercury.....	133.2	1.3595	13.595	1	1.3158×10^{3}	1.9337×10^{-2}	2.7845
Atmosphere.............	1013200.	1033.3	10333	760	1	14.696	2116.32
Pound per square inch....	68944	70.308	703.12	51.715	6.8046×10^{-2}	1	144
Pound per square foot....	478.78	4.883×10^{-1}	4.883	3.5912×10^{-1}	4.7252×10^{-4}	6.9445×10^{-3}	1

In the two tables above the numbers show the value of the energy or pressure unit named at the left in the units named at the top. For example, 1 gram-calorie is equivalent to 3.968×10^{-3} B.T.U.

COMPARISON OF METRIC AND CUSTOMARY UNITS FROM 1 TO 10

Length

INCHES		MILLI-METERS	INCHES		CENTI-METERS	FEET		METERS	U. S. YARDS		METERS	U. S. MILES		KILO-METERS
0.03937	=	**1**	0.3937	=	**1**	**1**	=	0.304801	**1**	=	0.914402	0.62137	=	**1**
0.07874	=	**2**	0.7874	=	**2**	**2**	=	0.609601	1.093611	=	**1**	**1**	=	1.60935
0.11811	=	**3**	**1**	=	2.54001	**3**	=	0.914402	**2**	=	1.828804	1.24274	=	**2**
0.15748	=	**4**	1.1811	=	**3**	3.28083	=	**1**	2.187222	=	**2**	1.86411	=	**3**
0.19685	=	**5**	1.5748	=	**4**	**4**	=	1.219202	**3**	=	2.743205	**2**	=	3.21869
0.23622	=	**6**	1.9685	=	**5**	**5**	=	1.524003	3.280833	=	**3**	2.48548	=	**4**
0.27559	=	**7**	**2**	=	5.08001	**6**	=	1.828804	**4**	=	3.657607	**3**	=	4.82804
0.31496	=	**8**	2.3622	=	**6**	6.56167	=	**2**	4.374444	=	**4**	3.10685	=	**5**
0.35433	=	**9**	2.7559	=	**7**	**7**	=	2.133604	**5**	=	4.572009	3.72822	=	**6**
1	=	25.4001	**3**	=	7.62002	**8**	=	2.438405	5.468056	=	**5**	**4**	=	6.43739
2	=	50.8001	3.1496	=	**8**	**9**	=	2.743205	**6**	=	5.486411	4.34959	=	**7**
3	=	76.2002	3.5433	=	**9**	9.84250	=	**3**	6.561667	=	**6**	4.97096	=	**8**
4	=	101.6002	**4**	=	10.16002	13.12333	=	**4**	**7**	=	6.400813	**5**	=	8.04674
5	=	127.0003	**5**	=	12.70003	16.40417	=	**5**	7.655278	=	**7**	5.59233	=	**9**
6	=	152.4003	**6**	=	15.24003	19.68500	=	**6**	**8**	=	7.315215	**6**	=	9.65608
7	=	177.8004	**7**	=	17.78004	22.96583	=	**7**	8.748889	=	**8**	**7**	=	11.26543
8	=	203.2004	**8**	=	20.32004	26.24667	=	**8**	**9**	=	8.229616	**8**	=	12.87478
9	=	228.6005	**9**	=	22.86005	29.52750	=	**9**	9.842500	=	**9**	**9**	=	14.48412

COMPARISON OF METRIC AND CUSTOMARY UNITS FROM 1 TO 10—Continued

Area

SQUARE INCHES		SQUARE MILLI-METERS	SQUARE INCHES		SQUARE CENTI-METERS	SQUARE FEET		SQUARE METERS	SQUARE YARDS		SQUARE METERS	SQUARE MILES		SQUARE KILO-METERS
0.00155	=	1	0.1550	=	1	1	=	0.09290	1	=	0.8361	0.3861	=	1
0.00310	=	2	0.3100	=	2	2	=	0.18581	1.1960	=	1	0.7722	=	2
0.00465	=	3	0.4650	=	3	3	=	0.27871	2	=	1.6723	1	=	2.5900
0.00620	=	4	0.6200	=	4	4	=	0.37161	2.3920	=	2	1.1583	=	3
0.0075	=	5	0.7750	=	5	5	=	0.46452	3	=	2.5084	1.5444	=	4
0.00930	=	6	0.9300	=	6	6	=	0.55742	3.5880	=	3	1.9305	=	5
0.01085	=	7	1	=	6.452	7	=	0.65032	4	=	3.3445	2	=	5.1800
0.01240	=	8	1.0850	=	7	8	=	0.74323	4.7839	=	4	2.3166	=	6
0.01395	=	9	1.2400	=	8	9	=	0.83613	5	=	4.1807	2.7027	=	7
1	=	645.16	1.3950	=	9	10.764	=	1	5.9799	=	5	3	=	7.7700
2	=	1,290.33	2	=	12.903	21.528	=	2	6	=	5.0168	3.0888	=	8
3	=	1,935.49	3	=	19.355	32.292	=	3	7	=	5.8529	3.4749	=	9
4	=	2,580.65	4	=	25.807	43.055	=	4	7.1759	=	6	4	=	10.3600
5	=	3,225.81	5	=	32.258	53.819	=	5	8	=	6.6890	5	=	12.9500
6	=	3,870.98	6	=	38.710	64.583	=	6	8.3719	=	7	6	=	15.5400
7	=	4,516.14	7	=	45.161	75.347	=	7	9	=	7.5252	7	=	18.1300
8	=	5,161.30	8	=	51.613	86.111	=	8	9.5679	=	8	8	=	20.7200
9	=	5,806.46	9	=	58.065	96.875	=	9	10.7639	=	9	9	=	23.3100

COMPARISON OF METRIC AND CUSTOMARY UNITS FROM 1 TO 10—Continued

Volume												AREA—Continued		
CUBIC INCHES		CUBIC MILLI-METERS	CUBIC INCHES		CUBIC CENTI-METERS	CUBIC FEET		CUBIC METERS	CUBIC YARDS		CUBIC METERS	ACRES		HECTARES
0.000061	=	1	0.0610	=	1	1	=	0.02832	1	=	0.7646	1	=	0.4047
0.000122	=	2	0.1220	=	2	2	=	0.05663	1.3079	=	1	2	=	0.8094
0.000183	=	3	0.1831	=	3	3	=	0.08495	2	=	1.5291	2.471	=	1
0.000244	=	4	0.2441	=	4	4	=	0.11327	2.6159	=	2	3	=	1.2141
0.000305	=	5	0.3051	=	5	5	=	0.14159	3	=	2.2937	4	=	1.6187
0.000366	=	6	0.3661	=	6	6	=	0.16990	3.9238	=	3	4.942	=	2
0.000427	=	7	0.4272	=	7	7	=	0.19822	4	=	3.0582	5	=	2.0234
0.000488	=	8	0.4882	=	8	8	=	0.22654	5	=	3.8228	6	=	2.4281
0.000549	=	9	0.5492	=	9	9	=	0.25485	5.2318	=	4	7	=	2.8328
1	=	16,387.2	1	=	16.3872	35.314	=	1	6	=	4.5874	7.413	=	3
2	=	32,774.3	2	=	32.7743	70.629	=	2	6.5397	=	5	8	=	3.2375
3	=	49,161.5	3	=	49.1615	105.943	=	3	7	=	5.3519	9	=	3.6422
4	=	65,548.6	4	=	65.5486	141.258	=	4	7.8477	=	6	9.884	=	4
5	=	81,935.8	5	=	81.9358	176.572	=	5	8	=	6.1165	12.355	=	5
6	=	98,323.0	6	=	98.3230	211.887	=	6	9	=	6.8810	14.826	=	6
7	=	114,710.1	7	=	114.7101	247.201	=	7	9.1556	=	7	17.297	=	7
8	=	131,097.3	8	=	131.0973	282.516	=	8	10.4635	=	8	19.768	=	8
9	=	147,484.5	9	=	147.4845	317.830	=	9	11.7715	=	9	22.239	=	9

COMPARISON OF METRIC AND CUSTOMARY UNITS FROM 1 TO 10—Continued

Capacity

MILLILITERS (CC.)		U. S. LIQUID OUNCES	MILLILITERS (CC.)		U. S. APOTHECARIES' DRAMS	U. S. APOTHECARIES' SCRUPLES		MILLILITERS (CC.)	U. S. LIQUID QUARTS		LITERS	U. S. LIQUID GALLONS		LITERS
1	=	0.03381	1	=	0.2705	0.8115	=	1	1	=	0.94636	0.26417	=	1
2	=	0.06763	2	=	0.5410	1	=	1.2322	1.05668	=	1	0.52834	=	2
3	=	0.10144	3	=	0.8115	1.6231	=	2	2	=	1.89272	0.79251	=	3
4	=	0.13526	3.6967	=	1	2	=	2.4645	2.11336	=	2	1	=	3.78543
5	=	0.16907	4	=	1.0820	2.4346	=	3	3	=	2.83908	1.05668	=	4
6	=	0.20288	5	=	1.3525	3	=	3.6967	3.17005	=	3	1.32085	=	5
7	=	0.23670	6	=	1.6231	3.2461	=	4	4	=	3.78543	1.58502	=	6
8	=	0.27051	7	=	1.8936	4	=	4.9290	4.22673	=	4	1.84919	=	7
9	=	0.30432	7.3934	=	2	4.0577	=	5	5	=	4.73179	2	=	7.57087
29.574	=	1	8	=	2.1641	4.8692	=	6	5.28341	=	5	2.11336	=	8
59.147	=	2	9	=	2.4346	5	=	6.1612	6	=	5.67815	2.37753	=	9
88.721	=	3	11.0901	=	3	5.6807	=	7	6.34009	=	6	3	=	11.35630
118.295	=	4	14.7869	=	4	6	=	7.3934	7	=	6.62451	4	=	15.14174
147.869	=	5	18.4836	=	5	6.4923	=	8	7.39677	=	7	5	=	18.92717
177.442	=	6	22.1803	=	6	7	=	8.6257	8	=	7.57088	6	=	22.71261
207.016	=	7	25.8770	=	7	7.3038	=	9	8.45345	=	8	7	=	26.49804
236.590	=	8	29.5737	=	8	8	=	9.8579	9	=	8.51723	8	=	30.28348
266.163	=	9	33.2704	=	9	9	=	11.0901	9.51014	=	9	9	=	34.06891

COMPARISON OF METRIC AND CUSTOMARY UNITS FROM 1 TO 10—Continued

U. S. DRY QUARTS	LITERS	U. S. PECKS	LITERS	DEKA-LITERS	U. S. PECKS.	U. S. BUSHELS	HECTO-LITERS	U. S. BUSHELS PER ACRE	HECTO-LITERS PER HECTARE
0.9081	= **1**	0.11351	= **1**	0.8810	= **1**	**1**	= 0.35239	**1**	= 0.87078
1	= 1.1012	0.22702	= **2**	**1**	= 1.1351	**2**	= 0.70479	1.14840	= **1**
1.8162	= **2**	0.34053	= **3**	1.7620	= **2**	2.83774	= **1**	**2**	= 1.74156
2	= 2.2025	0.45404	= **4**	**2**	= 2.2702	**3**	= 1.05718	2.29680	= **2**
2.7242	= **3**	0.56755	= **5**	2.6429	= **3**	**4**	= 1.40957	**3**	= 2.61233
3	= 3.3037	0.68106	= **6**	**3**	= 3.4053	**5**	= 1.76196	3.44519	= **3**
3.6323	= **4**	0.79457	= **7**	3.5239	= **4**	5.67548	= **2**	**4**	= 3.48311
4	= 4.4049	0.90808	= **8**	**4**	= 4.5404	**6**	= 2.11436	4.59359	= **4**
4.5404	= **5**	**1**	= 8.80982	4.4049	= **5**	**7**	= 2.46675	**5**	= 4.35389
5	= 5.5061	1.02157	= **9**	**5**	= 5.6755	**8**	= 2.81914	5.74199	= **5**
5.4485	= **6**	**2**	= 17.61964	5.2859	= **6**	8.51323	= **3**	**6**	= 5.22467
6	= 6.6074	**3**	= 26.42946	**6**	= 6.8106	**9**	= 3.17154	6.89039	= **6**
6.3565	= **7**	**4**	= 35.23928	6.1669	= **7**	11.35097	= **4**	**7**	= 6.09545
7	= 7.7086	**5**	= 44.04910	**7**	= 7.9457	14.18871	= **5**	**8**	= 6.96622
7.2646	= **8**	**6**	= 52.85892	7.0479	= **8**	17.02645	= **6**	8.03879	= **7**
8	= 8.8098	**7**	= 61.66874	7.9288	= **9**	19.86420	= **7**	**9**	= 7.83700
8.1727	= **9**	**8**	= 70.47856	**8**	= 9.0808	22.70194	= **8**	9.18719	= **8**
9	= 9.9110	**9**	= 79.28838	**9**	= 10.2159	25.53968	= **9**	10.33558	= **9**

COMPARISON OF METRIC AND CUSTOMARY UNITS FROM 1 TO 10—Continued

Weight (or Mass)

GRAINS	GRAMS	AVOIRDUPOIS OUNCES	GRAMS	TROY OUNCES	GRAMS	AVOIRDUPOIS POUNDS	KILOGRAMS	TROY POUNDS	KILOGRAMS
1	= 0.06480	0.03527	= 1	0.03215	= 1	1	= 0.45359	1	= 0.37324
2	= 0.12960	0.07055	= 2	0.06430	= 2	2	= 0.90718	2	= 0.74648
3	= 0.19440	0.10582	= 3	0.09645	= 3	2.20462	= 1	2.67923	= 1
4	= 0.25920	0.14110	= 4	0.12860	= 4	3	= 1.36078	3	= 1.11973
5	= 0.32399	0.17637	= 5	0.16075	= 5	4	= 1.81437	4	= 1.49297
6	= 0.38879	0.21164	= 6	0.19290	= 6	4.40924	= 2	5	= 1.86621
7	= 0.45359	0.24692	= 7	0.22506	= 7	5	= 2.26796	5.35846	= 2
8	= 0.51839	0.28219	= 8	0.25721	= 8	6	= 2.72155	6	= 2.23945
9	= 0.58319	0.31747	= 9	0.28936	= 9	6.61387	= 3	7	= 2.61269
15.4324	= 1	1	= 28.3495	1	= 31.10348	7	= 3.17515	8	= 2.98593
30.8647	= 2	2	= 56.6991	2	= 62.20696	8	= 3.62874	8.03769	= 3
46.2971	= 3	3	= 85.0486	3	= 93.31044	8.81849	= 4	9	= 3.35918
61.7294	= 4	4	= 113.3981	4	= 124.41392	9	= 4.08233	10.71691	= 4
77.1618	= 5	5	= 141.7476	5	= 155.51740	11.02311	= 5	13.39614.	= 5
92.5941	= 6	6	= 170.0972	6	= 186.62088	13.22773	= 6	16.07537	= 6
108.0265	= 7	7	= 198.4467	7	= 217.72437	15.43236	= 7	18.75460	= 7
123.4589	= 8	8	= 226.7962	8	= 248.82785	17.63698	= 8	21.43383	= 8
138.8912	= 9	9	= 255.1457	9	= 279.93133	19.84160	= 9	24.11306	= 9

WIRE TABLES

COMPARISON OF WIRE GAUGES

DIAMETER OF WIRE IN INCHES

Gauge No.	Brown & Sharpe.	Birmingham or Stub's.	Washburn & Moen.	Imperial or Brit. Std.	Stub's Steel.	U. S. Std. plate.	Music wire.
00000000	.....	....	....	....	..	....	.0083
0000000	.....	....	....	.500	..	....	.0087
000000	.....	....	....	.464	..	.46875	.0095
00000	.....	....	....	.432	..	.4375	.0100
0000	.4600	.454	3938	.400	..	.40625	.0110
000	.4096	.425	.3625	.372	..	.375	.0120
00	.3648	.380	.3310	.348	..	.34375	.0133
0	.3249	.340	.3065	.324	..	.3125	.0144
1	.2893	.300	.2830	.300	.227	.28125	.0156
2	.2576	.284	.2625	.276	.219	.265625	.0166
3	.2294	.259	.2437	.252	.212	.25	.0178
4	.2043	.238	.2253	.232	.207	.234375	.0188
5	.1819	.220	.2070	.212	.204	.21875	.0202
6	.1620	.203	.1920	.192	.201	.203125	.0215
7	.1443	.180	.1770	.176	.199	.1875	.0230
8	.1285	.165	.1620	.160	.197	.171875	.0243
9	.1144	.148	.1483	.144	.194	.15625	.0256
10	.1019	.134	.1350	.128	.191	.140625	.0270
11	.09074	.120	.1205	.116	.188	.125	.0284
12	.08081	.109	.1055	.104	.185	.109375	.0296
13	.07196	.095	.0915	.092	.182	.09375	.0314
14	.06408	.083	.0800	.080	.180	.078125	.0326
15	.05707	.072	.0720	.072	.178	.0703125	.0345
16	.05082	.065	.0625	.064	.175	.0625	.0360
17	.04526	.058	.0540	.056	.172	.05625	.0377
18	.04030	.049	.0475	.048	.168	.05	.0395
19	.03589	.042	.0410	.040	.164	.04375	.0414
20	.03196	.035	.0348	.036	.161	.0375	.0434
21	.02846	.032	.0318	.032	.157	.034375	.0460
22	.02535	.028	.0286	.028	.155	.03125	.0483
23	.02257	.025	.0258	.024	.153	.028125	.0515
24	.02010	.022	.0230	.022	.151	.025	.0550

COMPARISON OF WIRE GAUGES (Continued)

DIAMETER OF WIRE IN INCHES

Gauge No.	Brown & Sharpe.	Birmingham or Stub's.	Washburn & Moen.	Imperial or Brit. Std.	Stub's steel.	U. S. Std. plate.	Music wire.
25	.01790	.020	.0204	.020	.148	.021875	.0586
26	.01594	.018	.0181	.018	.146	.01875	.0626
27	.01419	.016	.0173	.0164	.143	.0171875	.0658
28	01264	.014	.0162	.0149	.139	.015625	.0720
29	.01126	.013	.0150	.0136	.134	.0140625	.0760
30	.01003	.012	.0140	.0124	.127	.0125	.0800
31	.008928	.010	.0132	.0116	.120	.0109375	0820
32	.007950	.009	.0128	.0108	.115	.01015625	.0860
33	.007080	.008	.0118	.0100	.112	.009375	.0900
34	.006304	.007	.0104	.0092	.110	.00859375	.0950
35	.005614	.005	.0095	.0084	.108	.0078125	
36	.005000	.004	.0090	.0076	.106	.00703125	
37	.004453	....	....	.0068	.103	.006640625	
38	.003965	....	....	.0060	.101	.00625	
39	.003531	....	....	.0052	.099		
40	.003145	....	....	.0048	.097		

TWIST DRILL AND STEEL WIRE GAUGE

INCHES

No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
1	.2280	11	.1910	21	.1590	31	.1200	41	.0960	51	.0670
2	.2210	12	.1890	22	.1570	32	.1160	42	.0935	52	.0635
3	.2130	13	.1850	23	.1540	33	.1130	43	.0890	53	.0595
4	.2090	14	.1820	24	.1520	34	.1110	44	.0860	54	.0550
5	.2055	15	.1800	25	.1495	35	.1100	45	.0820	55	.0520
6	.2040	16	.1770	26	.1470	36	.1065	46	.0810	56	.0465
7	.2010	17	.1730	27	.1440	37	.1040	47	.0785	57	.0430
8	.1990	18	.1695	28	.1405	38	.1015	48	.0760	58	.0420
9	.1960	19	.1660	29	.1360	39	.0995	49	.0730	59	.0410
10	.1935	20	.1610	30	.1285	40	.0980	50	.0700	60	.0400

DIMENSIONS OF WIRE

Stub's Gauge

Giving the diameter and cross-section in English and metric system for the Birmingham or Stub's gauge.

Gauge No.	Diameter in ins.	Section in sq.ins.	Diameter in cms.	Section in sq.cms.
0000	0.454	0.16188	1.1532	1.0444
000	.425	.14186	.0795	0.9152
00	.380	.11341	0.9652	.7317
0	.340	.09079	.8636	.5858
1	0.300	0.07069	0.7620	0.4560
2	.284	.06335	.7214	.4087
3	.259	.05269	.6579	.3399
4	.238	.04449	.6045	.2870
5	.220	.03801	.5588	.2452
6	0.203	0.03237	0.5156	0.20881
7	.180	.02545	.4572	.16147
8	.165	.02138	.4191	.13795
9	.148	.01720	.3759	.11099
10	.134	.01410	.3404	.09098
11	0.120	0.011310	0.3048	0.07297
12	.109	.009331	.2769	.06160
13	.095	.007088	.2413	.04573
14	.083	.005411	.2108	.03491
15	.072	.004072	.1829	.02627
16	0.065	0.0033183	0.16510	0.021409
17	.058	.0026421	.14732	.017046
18	.049	.0018857	.12446	.012166
19	.042	.0013854	.10668	.008938
20	.035	.0009621	.08890	.006207
21	0.032	0.0008042	0.08128	0.005189
22	.028	.0006158	.07112	.003973
23	.025	.0004909	.06350	.003167
24	.022	.0003801	.05588	.002452
25	.020	.0003142	.05080	.002027
26	0.018	0.0002545	0.04572	0.0016417
27	.016	.0002011	.04064	.0012972
28	.014	.0001539	.03556	.0009932
29	.013	.0001327	.03302	.0008563
30	.012	.0001181	.03048	.0007297
31	0.010	0.00007854	0.02540	0.0005067
32	.009	.00006362	.02286	.0004104
33	.008	.00005027	.02032	.0003243
34	.007	.00003848	.01778	.0002483
35	.005	.00001963	.01270	.0001267
36	0.004	0.00001257	0.01016	0.0000811

DIMENSIONS OF WIRE (Continued)

British Standard Gauge

Giving the diameter and cross-section in English and metric system for the British Standard Gauge.

Gauge No.	Diameter in ins.	Section in sq.ins.	Diameter in cms.	Section in sq.cms.
7-0	0.500	0.1963	1.2700	1.267
6-0	.464	.1691	.1786	.091
5-0	0.432	0.1466	1.0973	0.9456
4-0	.400	.1257	.0160	.8107
3-0	.372	.1087	0.9449	.7012
2-0	.348	.0951	.8839	.6136
0	.324	.0825	.8230	.5319
1	0.300	0.07069	0.7620	0.4560
2	.276	.05983	.7010	.3858
3	.252	.04988	.6401	.3218
4	.232	.04227	.5893	.2727
5	.212	.03530	.5385	.2277
6	0.192	0.02895	0.4877	0.18679
7	.176	.02433	.4470	.15696
8	.160	.02010	.4064	.12973
9	.144	.01629	.3658	.10507
10	.128	.01287	.3251	.08302
11	0.116	0.010568	0.2946	0.06818
12	.104	.008495	.2642	.05480
13	.092	.006648	.2337	.04289
14	.080	.005027	.2032	.03243
15	.072	.004071	.1829	.02627
16	0.064	0.003217	0.16256	0.020755
17	.056	.002463	.14224	.015890
18	.048	.001810	.12192	.011675
19	.040	.001257	.10160	.008107
20	.036	.001018	.09144	.006567
21	0.032	0.0008042	0.08128	0.005189
22	.028	.0006158	.07112	.003973
23	.024	.0004524	.06096	.002922
24	.022	.0003801	.05588	.002452
25	.020	.0003142	.05080	.002027
26	0.0180	0.0002545	0.04572	0.0016417
27	.0164	.0002112	.04166	.0013628
28	.0148	.0001728	.03759	.0011099
29	.0136	.0001453	.03454	.0009363
30	.0124	.0001208	.03150	.0007791
31	0.0116	0.00010568	0.02946	0.0006818
32	.0108	00009161	.02743	.0005910
33	.0100	.00007854	.02540	.0005067
34	.0092	.00006648	.02337	.0004289
35	.0084	.00005542	.02134	.0003575
36	0.0076	0.00004536	0.01930	0.0002927
37	.0068	.00003632	.01727	.0002343
38	.0060	.00002827	.01524	.0001824
39	.0052	.00002124	.01321	.0001370
40	.0048	.00001810	.01219	.0001167
41	0.0044	0.00001521	0.01118	0.0000982
42	.0040	.00001257	.01016	.0000811
43	.0036	.00001018	.00914	.0000656
44	.0032	.00000804	.00813	.0000519
45	.0028	.00000616	.00711	.0000397
46	0.0024	0.00000452	0.00610	0.0000212
47	.0020	.00000314	.00508	.0000203
48	.0016	00000201	.00406	.0000129
49	.0012	.00000113	.00305	.0000073
50	.0010	.00000079	00254	0000051

DIMENSIONS OF WIRE, B. & S. GAUGE, U. S.

Diameter and cross-section of wires, Brown & Sharpe Gauge, mass of pure hard-drawn copper wire at 32° F. (density 8.90).

Gauge number.	Diam. in ins.	Cross-section in sq.in.	Pounds per ft.	Feet per lb.
0000	0.4600	0.1662	0.6412	1.560
000	.4096	.1318	.5085	1.967
00	.3648	.1045	.4033	2.480
0	.3249	.0829	.3198	3.127
1	0.2893	0.06573	0.2536	3.943
2	.2576	.05213	.2011	4.972
3	.2294	.04134	.1595	6.270
4	.2043	.03278	.1265	7.905
5	.1819	.02600	.1003	9.969
6	0.1620	0.02062	0.07955	12.57
7	.1443	.01635	.06309	15.85
8	.1285	.01297	.05003	19.99
9	.1144	.01028	.03968	25.20
10	.1019	.00815	.03146	31.78
11	0.09074	0.006467	0.02495	40.08
12	.08081	.005129	.01979	50.54
13	.07196	.004067	.01569	63.72
14	.06408	.003225	.01244	80.35
15	.05707	.002558	.00987	101.32
16	0.05082	0.002028	0.007827	127.8
17	.04526	.001609	.006207	161.1
18	.04030	.001276	.004922	203.2
19	.03589	.001012	.003904	256.2
20	.03196	.000802	.003096	323.1
21	0.02846	0.0006363	0.002455	408.2
22	.02535	.0005046	.001947	513.6
23	.02257	.0004001	.001544	647.7
24	.02010	.0003173	.001224	816.7
25	.01790	.0002517	.000971	1029.9
26	0.01594	0.0001996	0.0007700	1298.
27	.01419	.0001583	.0006107	1638.
28	.01264	.0001255	.0004843	2065.
29	.01126	.0000995	.0003841	2604.
30	.01003	.0000789	.0003046	3283.
31	0.008928	0.00006260	0.0002415	4140.
32	.007950	.00004964	.0001915	5221.
33	.007080	.00003937	.0001519	6583.
34	.006304	.00003122	.0001205	8301.
35	.005614	.00002476	.0000955	10468.
36	0.005000	0.00001963	0.00007576	13200.
37	.004453	.00001557	.00006008	16644.
38	.003965	.00001235	.00004765	20988.
39	.003531	.00000979	.00003778	26465.
40	.003145	.00000777	.00002996	33372.

MASS AND RESISTANCE FOR COPPER

Measure

Electrical resistance of pure hard-drawn copper wire at 32° F. (density 8.90.)

Gauge number.	Ohms per ft.	Ft. per ohm.	Ohms per lb.	Lbs. per ohm.
0000	0.00004629	21601.	0.00007219	13852.
000	.00005837	17131.	.00011479	8712.
00	.00007361	13586.	.00018253	5479.
0	.00009282	10774.	.00029023	3445.
1	0.0001170	8544.	0.0004615	2166.8
2	.0001476	6775.	.0007338	1362.8
3	.0001861	5373.	.0011668	857.0
4	.0002347	4261.	.0018552	539.0
5	.0002959	3379.	.0029499	339.0
6	0.0003731	2680.	0.004690	213.22
7	.0004705	2125.	.007458	134.08
8	.0005933	1685.	.011859	84.32
9	.0007482	1337.	.018857	53.03
10	.0009434	1060.	.029984	33.35
11	0.001190	840.6	0.04768	20.973
12	.001500	666.6	.07581	13.191
13	.001892	528.7	.12054	8.296
14	.002385	419.2	.19166	5.218
15	.003008	332.5	.30476	3.281
16	0.003793	263.7	0.4846	2.0636
17	.004783	209.1	.7705	1.2979
18	.006031	165.8	1.2252	0.8162
19	.007604	131.5	1.9481	.5133
20	.009589	104.3	3.0976	.3228
21	0.01209	82.70	4.925	0.20305
22	.01525	65.59	7.832	.12768
23	.01923	52.01	12.453	.08030
24	.02424	41.25	19.801	.05051
25	.03057	32.71	31.484	.03176
26	0.03855	25.94	50.06	0.019976
27	.04861	20.57	79.60	.012563
28	.06130	16.31	126.57	.007901
29	.07729	12.94	201.26	.004969
30	.09746	10.26	320.01	.003125
31	0.1229	8.137	508.8	0.0019654
32	.1550	6.452	809.1	.0012359
33	.1954	5.117	1286.5	.0007773
34	.2464	4.058	2045.6	.0004889
35	.3107	3.218	3252.6	.0003074
36	0.3918	2.552	5172.	0.0001934
37	.4941	2.024	8224.	.0001216
38	.6230	1.605	13076.	.0000765
39	.7856	1.273	20792.	.0000481
40	.9906	1.009	33060.	.0000303

DIMENSIONS OF WIRE B. & S. GAUGE,

Metric

Diameter, cross-section of wires, Brown & Sharpe gauge, mass of pure hard-drawn copper wire at 0° C. (density 8.90).

Gauge number.	Diam. in cm.	Cross-section in sq.cm.	Grams per meter.	Meters per gram.
0000	1.1684	1.0722	954.3	0.001048
000	.0405	0.8503	756.8	.001322
00	0.9266	.7643	600.1	.001666
0	.8251	.5348	475.9	.002101
1	0.7348	0.4241	377.4	0.002649
2	.6544	.3363	299.3	.003341
3	.5827	.2667	237.4	.004213
4	.5189	.2115	188.2	.005312
5	.4621	.1677	149.3	.006699
6	0.4115	0.13302	118.39	0.00845
7	.3665	.10549	93.88	.01065
8	.3264	.08366	74.45	.01343
9	.2906	.06634	59.04	.01694
10	.2588	.05261	46.82	.02136
11	0.2305	0.04172	37.13	0.02693
12	.2053	.03309	29.45	.03396
13	.1828	.02624	23.35	.04282
14	.1628	.02081	18.52	.05400
15	.1450	.01650	14.69	.06809
16	0.12908	0.013087	11.648	0.0859
17	.11495	.010378	9.237	.1083
18	.10237	.008231	7.325	.1365
19	.09116	.006527	5.809	.1721
20	.08118	.005176	4.607	.2171
21	0.07229	0.004105	3.653	0.2737
22	.06438	.003255	2.898	.3450
23	.05733	.002582	2.298	.4352
24	.05106	.002047	1.822	.5488
25	.04545	.001624	1.445	.6920
26	0.04049	0.0012876	1.1459	0.873
27	.03606	.0010211	.9088	1.100
28	.03211	.0008098	.7207	1.388
29	.02859	.0006422	.5715	1.750
30	.02546	.0005093	.4532	2.206
31	0.02268	0.0004039	0.3594	2.782
32	.02019	.0003203	.2850	3.508
33	.01798	.0002540	.2261	4.424
34	.01601	.0002014	.1793	5.578
35	.01426	.0001597	.1422	7.034
36	0.01270	0.0001267	0.1127	8.87
37	.01131	.0001005	.0894	11.18
38	.01007	.0000797	.0709	14.10
39	.00897	.0000632	.0562	17.78
40	.00799	.0000501	.0446	22.43

MASS AND RESISTANCE FOR COPPER (Continued)

System

Electrical resistance of pure hard-drawn copper wire at 0° C. (density 8.90).

Gauge number.	Ohms per meter.	Meters per ohm.	Ohms per gram.	Grams per ohm.
0000	0.0001519	6584.	0.0000001592	6283000.
000	.0001915	5221.	.0000002531	3951000.
00	.0002415	4141.	.0000004024	2485000.
0	.0003045	3284.	.0000006398	1563000.
1	0.0003840	2604.	0.000001017	928900.
2	.0004842	2065.	.000001618	618200.
3	.0006106	1638.	.000002572	388800.
4	.0007699	1299.	.000004090	244500.
5	.0009709	1030.	.000006504	153800.
6	0.001224	816.9	0.00001034	96700.
7	.001544	647.8	.00001644	60820.
8	.001947	513.7	.00002615	38250.
9	.002455	407.4	.00004157	24050.
10	.003095	323.1	.00006610	15130.
11	0.003903	256.2	0.00010511	9514.
12	.004922	203.2	.00016712	5984.
13	.006206	161.1	.00026574	3763.
14	.007826	127.8	.00042254	2367.
15	.009868	101.3	.00067187	1488.
16	0.01244	80.37	0.0010683	936.1
17	.01569	63.73	.0016987	588.7
18	.01979	50.54	.0027010	370.2
19	.02495	40.08	.0042948	232.8
20	.03146	31.79	.0068290	146.4
21	0.03967	25.21	0.010859	92.09
22	.05002	19.99	.017266	57.92
23	.06308	15.85	.027454	36.42
24	.07954	12.57	.043653	22.91
25	.10030	9.97	.069411	11.88
26	0.12647	7.907	0.11037	9.060
27	.15948	6.270	.17549	5.698
28	.20110	4.973	.27904	3.584
29	.25358	3.943	.44369	2.254
30	.31976	3.127	.70550	1.417
31	0.4032	2.480	1.1218	0.8914
32	.5084	1.967	1.7837	.5606
33	.6411	1.560	2.8362	.3526
34	.8085	1.237	4.5097	.2217
35	1.0194	0.981	7.1708	.1394
36	1.2855	0.7779	11.376	0.08790
37	1.6210	.6169	18.130	.05516
38	2.0440	.4892	28.828	.03469
39	2.5775	.3880	45.838	.02182
40	3.2501	.3076	72.885	.01372

CROSS-SECTION AND MASS OF WIRES

U. S. Measure

Diameters are given in mils (1 mil = .001 in.), and area in square mils (1 sq. mil = .000001 sq.in.). For sections and masses for one-tenth the diameters given, divide by 100 and for sections and masses for ten times the diameter multiply by 100.

Diam. in mils.	Cross-sec. in sq. mils.	Pounds per foot.			
		Copper, density 8.90.	Iron, density 7.80.	Brass, density 8.56.	Aluminum, density 2.67.
10	78.54	0.000303	0.0002656	0.0002915	0.0000909
11	95.03	0367	03214	03527	01100
12	113.10	0436	03825	04197	01309
13	132.73	0512	04488	04926	01536
14	153.94	0594	05206	05713	01782
15	176.71	0.000682	0.0005976	0.0006558	0.0002045
16	201.06	0776	06799	07461	02327
17	226.98	0876	07675	08423	02627
18	254.47	0982	08605	09443	02946
19	283.53	1094	09588	10522	03282
20	314.16	0.001212	0.001062	0.001166	0.0003636
21	346.36	1336	1171	1285	04009
22	380.13	1467	1286	1411	04400
23	415.48	1603	1405	1542	04809
24	452.39	1746	1530	1679	05237
25	490.87	0.001894	0.001660	0.001822	0.0005682
26	530.93	2046	1795	1970	06147
27	572.56	2209	1936	2125	06628
28	615.75	2376	2082	2285	07127
29	660.52	2549	2234	2451	07646
30	706.86	0.002727	0.002390	0.002623	0.0008182
31	754.77	2912	2552	2801	08737
32	804.25	3103	2720	2985	09309
33	855.30	3300	2892	3174	09900
34	907.92	3503	3070	3369	10509
35	962.11	0.003712	0.003253	0.003570	0.001114
36	1017.88	3927	3442	3777	1178
37	1075.21	4149	3636	3990	1245
38	1134.11	4376	3844	4218	1316
39	1194.59	4609	4040	4433	1383
40	1256.64	0.004849	0.004249	0.004664	0.001455
41	1320.25	5094	4465	4900	1528
42	1385.44	5346	4685	5141	1604
43	1452.20	5603	4911	5389	1681
44	1520.53	5867	5142	5643	1760
45	1590.43	0.006137	0.005378	0.005902	0.001841
46	1661.90	6412	5620	6167	1924
47	1734.94	6694	5867	6438	2008
48	1809.56	6982	6119	6715	2095
49	1885.74	7276	6377	6998	2183
50	1963.50	0.007576	0.006640	0.007287	0.002273
51	2042.82	7882	6908	7581	2365
52	2123.72	8194	7181	7881	2458
53	2206.18	8512	7460	8187	2554
54	2290.22	8837	7744	8499	2651

CROSS-SECTION AND MASS OF WIRES (Continued)

U. S. Measure (Continued)

Diameters are given in mils (1 mil = .001 in.), and area in square mils (1 sq. mil = .000001 sq. in.). For sections and masses for one-tenth the diameters given, divide by 100 and for sections and masses for ten times the diameter multiply by 100.

Diam. in mils.	Cross-sec. in sq. mils.	Pounds per foot. Copper, density 8.90.	Iron, density 7.80.	Brass, density 8.56.	Aluminum, density 2.67.
55	2375.83	0.009167	0.008034	0.008817	0.002750
56	2463.01	09504	08329	09140	2851
57	2551.76	09846	08629	09470	2954
58	2642.08	10195	08934	09805	3058
59	2733.97	10549	09245	10146	3165
60	2827.43	0.01091	0.00956	0.01049	0.003273
61	2922.47	1128	0988	1085	3383
62	3019.07	1165	1021	1120	3495
63	3117.25	1203	1054	1157	3608
64	3216.99	1241	1088	1194	3724
65	3318.31	0.01280	0.01122	0.01231	0.003841
66	3421.19	1320	1157	1270	3960
67	3525.65	1360	1192	1308	4081
68	3631.68	1401	1228	1348	4204
69	3739.28	1443	1264	1388	4328
70	3848.45	0.01485	0 01302	0.01429	0.004456
71	3959.19	1528	1339	1469	4583
72	4071.50	1571	1377	1511	4713
73	4185.39	1615	1415	1553	4845
74	4300.84	1660	1454	1596	4978
75	4417.86	0.01705	0.01494	0.01639	0.005114
76	4536.46	1751	1534	1684	5251
77	4656.63	1797	1575	1728	5390
78	4778.36	1844	1616	1773	5531
79	4901.67	1892	1658	1819	5674
80	5026.55	0.01939	0.01700	0.01865	0.005818
81	5153.00	1988	1743	1912	5965
82	5281.02	2038	1786	1960	6113
83	5410.61	2088	1830	2008	6263
84	5541.77	2138	1874	2057	6415
85	5674.50	0.02189	0.01919	0.02106	0.006568
86	5808.80	2241	1964	2156	6724
87	5944.68	2294	2010	2206	6881
88	6082.12	2347	2057	2257	7040
89	6221.14	2400	2104	2309	7201
90	6361.73	0.02455	0.02151	0.02360	0.007364
91	6503.88	2509	2199	2414	7528
92	6647.61	2565	2248	2467	7695
93	6792.91	2621	2297	2521	7863
94	6939.78	2678	2347	2575	8033
95	7088.22	0.02735	0.02397	0.02630	0.008205
96	7238.23	2793	2448	2686	8378
97	7389.81	2851	2499	2742	8554
98	7542.96	2910	2551	2799	8731
99	7697.69	2970	2603	2857	8910
100	7853.98	0.03030	0.02656	0.02915	0.009091

CROSS-SECTION AND MASS OF WIRES (Continued)

Metric Measure

Diameters are given in thousandths of a centimeter and area of section in square thousandths of a centimeter. 1 (cm./1000)^2 = .000001 sq. cm. For sections and masses for diameters 1/10 or 10 times those of the table, divide or multiply by 100.

Diam. in thousandths of a cm.	Cross-section in square thousandths of a cm.	Grams per meter.			
		Copper, density 8.90.	Iron, density 7.80.	Brass, density 8.56.	Aluminum, density 2.67.
10	78.54	0.06990	0.06126	0.06723	0.02097
11	95.03	.08458	.07412	.08135	.02537
12	113.10	.10065	.08822	.09681	.03020
13	132.73	.11813	.10353	.11362	.03544
14	153.94	.13701	.12008	.13177	.04110
15	176.71	0.1573	0.1378	0.1513	0.04718
16	201.06	.1789	.1568	.1721	.05368
17	226.98	.2020	.1770	.1943	.06060
18	254.47	.2265	.1985	.2178	.06794
19	283.53	.2523	.2212	.2427	.07570
20	314.16	0.2796	0.2450	0.2689	0.08388
21	346.36	.3083	.2702	.2965	.09248
22	380.13	.3383	.2965	.3254	.10149
23	415.48	.3698	.3241	.3557	.11093
24	452.39	.4026	.3529	.3872	.12079
25	490.87	0.4369	0.3829	0.4202	0.1311
26	530.93	.4725	.4141	.4545	.1418
27	572.56	.5096	.4466	.4901	.1529
28	615.75	.5480	.4803	.5271	.1644
29	660.52	.5879	.5152	.5654	.1764
30	706.86	0.6291	0.5514	0.6051	0.1887
31	754.77	.6717	.5887	.6461	.2015
32	804.25	.7158	.6273	.6884	.2147
33	855.30	.7612	.6671	.7321	.2284
34	907.92	.8081	.7082	.7772	.2424
35	962.11	0.856	0.7504	0.8236	0.2569
36	1017.88	.906	.7939	.8713	.2718
37	1075.21	.957	.8387	.9204	.2871
38	1134.11	1.012	.8866	.9730	.3035
39	1194.59	.063	.9318	1.0230	.3190
40	1256.64	1.118	0.980	1.076	0.3355
41	1320.25	.175	1.030	.130	.3525
42	1385.44	.233	.081	.186	.3699
43	1452.20	.292	.133	.243	.3877
44	1520.53	.353	.186	.302	.4060
45	1590.43	1.415	1.241	1.361	0.4246
46	1661.90	.479	.296	.423	.4437
47	1734.94	.544	.353	.485	.4632
48	1809.56	.611	.411	.549	.4832
49	1885.74	.678	.471	.614	.5035
50	1963.50	1.748	1.532	1.681	.5243
51	2042.82	.818	.593	.753	.5454
52	2123.72	.890	.657	.818	.5670
53	2206.18	.964	.721	.888	.5891
54	2290.22	2.038	.786	.960	.6115

CROSS-SECTION AND MASS OF WIRES (Continued)

Metric Measure (Continued)

Diameters are given in thousandths of a centimeter and area of section in square thousandths of a centimeter. 1 (cm. /1000)^2 = .000001 sq. cm. For sections and masses for diameters 1/10 or 10 times those of the table, divide or multiply by 100.

Diam. in thousandths of a cm.	Cross-section in square thousandths of a cm.	Grams per meter.			
		Copper, density 8.90.	Iron, density 7.80.	Brass, density 8.56.	Aluminum, density 2.67.
55	2375.83	2.114	1.853	2.034	0.6343
56	2463.01	.192	.921	.108	.6576
57	2551.76	.271	.990	.184	.6813
58	2642.08	.351	2.061	.262	.7054
59	2733.97	.433	.132	.340	.7300
60	2827.43	2.516	2.205	2.420	0.7549
61	2922.47	.601	.280	.502	.7803
62	3019.07	.687	.355	.584	.8061
63	3117.25	.774	.431	.668	.8323
64	3216.99	.863	.509	.760	.8589
65	3318.31	2.953	2.588	2.840	0.8860
66	3421.19	3.045	.669	.929	.9135
67	3525.65	.138	.750	3.018	.9413
68	3631.68	.232	.833	.109	.9697
69	3739.28	.328	.917	.201	.9984
70	3848.45	3.426	3.003	3.295	1.028
71	3959.19	.524	.088	.389	.057
72	4071.50	.624	.176	.485	.087
73	4185.39	.725	.265	.583	.117
74	4300.84	.828	.355	.682	.148
75	4417.86	3.932	3.446	3.782	1.180
76	4536.46	4.037	.538	.883	.211
77	4656.63	.144	.632	.986	.243
78	4778.36	.253	.727	4.090	.276
79	4901.67	.362	.823	.177	.309
80	5026.55	4.474	3.921	4.303	1.342
81	5153.00	.586	4.019	.411	.376
82	5281.02	.700	.119	.521	.410
83	5410.61	.815	.220	.631	.445
84	5541.77	.932	.323	.744	.480
85	5674.50	5.050	4.426	4.857	1.515
86	5808.80	.170	.531	.972	.551
87	5944.68	.291	.637	5.089	.587
88	6082.12	.413	.744	.206	.624
89	6221.14	.537	.852	.325	.661
90	6361.73	5.662	4.962	5.446	1.699
91	6503.88	.788	5.073	.567	.737
92	6647.61	.916	.185	.690	.775
93	6792.91	6.046	.298	.815	.814
94	6939.78	.176	.413	.940	.853
95	7088.22	6.309	5.529	6.068	1.893
96	7238.23	.442	.646	.196	.933
97	7389.81	.577	.764	.326	.973
98	7542.96	.713	.884	.457	2.014
99	7697.69	.851	6.004	.589	.055
100	7853.98	6.990	6.126	6.723	2.097

PLATINUM WIRE TABLE, BROWN & SHARPE GAUGE

GIVING DIAMETER AND APPROXIMATE MASS

Gauge No.	10	11	12	13	14	15	16
Diameter in dec. in....	0.106	0.091	0.081	0.072	0.064	0.057	0.051
Approximate mass in grams, per foot.....	37.5	28.0	22.0	17.5	14.0	11.0	9.0
Gauge No.	17	18	19	20	21	22	
Diameter in dec. in...	0.045	0.041	0.036	0.032	0.029	0.026	
Approximate mass in grams, per foot.....	7.0	5.7	4.4	3.4	2.9	2.3	
Gauge No.	23	24	25	26	27	28	
Diameter in dec. in...	0.023	0.020	0.018	0.016	0.014	0.013	
Approximate mass in in grams, per foot...	1.8	1.4	1.1	0.9	0.7	0.6	
Gauge No.	29	30	31	32	33	34	35
Diameter in dec. in...	0.0115	0.010	0.009	0.008	0.007	0.0063	0.0056
Approximate mass in in grams, per foot...	0.45	0.35	0.28	0.22	0.17	0.15	0.11

RESISTANCE OF ALUMINUM WIRE

GIVING THE RESISTANCE OF HARD DRAWN ALUMINUM WIRE AT 20° C.

(From the Bureau of Standards.)

Gauge number.	Ohms per 1000 ft.	Ohms per kilometer.	Gauge number.	Ohms per 1000 ft.	Ohms per kilometer.
0000	0.0804	0.264	20	16.7	54.6
000	.101	.333	21	21.0	68.9
00	.128	.419	22	26.5	86.9
0	.161	.529	23	33.4	110.
1	.203	.667	24	42.1	138.
2	.256	.841	25	53.1	174.
3	.323	1.06	26	67.0	220.
4	.408	1.34	27	84.4	277.
5	.514	1.69	28	106.	349.
6	.648	2.13	29	134.	440.
7	.817	2.68	30	169.	555.
8	1.03	3.38	31	213.	700.
9	1.30	4.26	32	269.	883.
10	1.64	5.38	33	339.	1110.
11	2.07	6.78	34	428.	1400.
12	2.61	8.55	35	540.	1770.
13	3.29	10.8	36	681.	2230.
14	4.14	13.6	37	858.	2820.
15	5.22	17.1	38	1080.	3550.
16	6.59	21.6	39	1360.	4480.
17	8.31	27.3	40	1720.	5640.
18	10.5	34.4			
19	13.2	43.3			

APPROXIMATE RESISTANCE OF WIRES

Giving the resistance in ohms of one centimeter length at 20°C. Owing to varying composition and physical condition, these values can be considered only as approximations.

Gauge No. B. & S.	Diam. in cms.	Brass	Con-stantin	German silver	Iron	Manganin
10	.2588	.00014	.00093	.00056	.00023	.00080
12	.2053	.00023	.00148	.00089	.00036	.00127
14	.1628	.00037	.0024	.00142	.00058	.0020
16	.1291	.00058	.0037	.0023	.00092	.0032
18	.1024	.00091	.0059	.0036	.00146	.0051
20	.08118	.00147	.0095	.0057	.0023	.0081
22	.06438	.0023	.0150	.0090	.0037	.0129
24	.05106	.0037	.024	.0144	.0059	.021
26	.04049	.0059	.038	.023	.0093	.033
27	.03606	.0075	.048	.029	.0118	.041
28	.03211	.0093	.061	.036	.0148	.052
30	.02546	.0147	.096	.058	.024	.083
32	.02019	.024	.153	.092	.038	.131
34	.01601	.038	.24	.148	.060	.209
36	.01270	.060	.39	.23	.094	.33
40	.00799	.15	.98	.59	.24	.84

MATHEMATICAL TABLES

ALGEBRA

Factors

$$(a \pm b)^2 = a^2 \pm 2ab + b^2$$
$$(a \pm b)^3 = a^3 \pm 3a^2b + 3ab^2 \pm b^3$$
$$a^2 - b^2 = (a - b)(a + b)$$
$$a^3 - b^3 = (a - b)(a^2 + ab + b^2)$$
$$a^3 + b^3 = (a + b)(a^2 - ab + b^2)$$
$$a^n - b^n = (a - b)(a^{n-1} + a^{n-2}b + \ldots + b^{n-1})$$
$$a^n - b^n = (a + b)(a^{n-1} - a^{n-2}b + \ldots - b^{n-1}),$$
for even values of n.
$$a^n + b^n = (a + b)(a^{n-1} - a^{n-2}b + \ldots + b^{n-1}),$$
for odd values of n.
$$a^4 + a^2b^2 + b^4 = (a^2 + ab + b^2)(a^2 - ab + b^2)$$
$$(a + b + c)^2 = a^2 + b^2 + c^2 + 2ab + 2ac + 2bc$$
$$(a + b + c)^3 = a^3 + b^3 + c^3 + 3a^2(b + c) + 3b^2(a + c) + 3c^2(a + b) + 6abc$$

Quadratic Equations

Any quadratic equation may be reduced to the form,—

$$ax^2 + bx + c = 0$$

Then $$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

If $b^2 - 4ac$ is positive the roots are real and unequal.
If $b^2 - 4ac$ is zero the roots are real and equal.
If $b^2 - 4ac$ is negative the roots are imaginary and unequal.
If $b^2 - 4ac$ is a perfect square the roots are rational and unequal.

Exponents

$$a^x \times a^y = a^{x+y} \qquad a^{-x} = \frac{1}{a^x}$$

$$\frac{a^x}{a^y} = a^{x-y} \qquad a^0 = 1$$

$$(a^x)^y = a^{xy} \qquad a^{\frac{x}{y}} = \sqrt[y]{a^x}$$

Proportion

If $$\frac{a}{b} = \frac{c}{d}$$

Then $$\frac{a+b}{b} = \frac{c+d}{d}$$

$$\frac{a-b}{b} = \frac{c-d}{d}$$

$$\frac{a-b}{a+b} = \frac{c-d}{c+d}$$

ALGEBRA (Continued)

Sums of Numbers

The sum of the first n numbers, —

$$\Sigma(n) = 1 + 2 + 3 + 4 + 5 \ldots\ldots + n = \frac{n(n+1)}{2}$$

The sum of the squares of the first n numbers,

$$\Sigma(n^2) = 1^2 + 2^2 + 3^2 + 4^2 + 5^2 \ldots\ldots + n^2 = \frac{n(n+1)(2n+1)}{6}$$

The sum of the cubes of the first n numbers,

$$\Sigma(n^3) = 1^3 + 2^3 + 3^3 + 4^3 + 5^3 \ldots\ldots + n^3 = \frac{n^2(n+1)^2}{4}$$

Arithmetical Progression

If a is the first term; l, the last term; d, the common difference; n, the number of terms and s, the sum of n terms, —

$$l = a + (n-1)d$$

$$s = \frac{n}{2}(a + l)$$

$$s = \frac{n}{2}\left\{2a + (n-1)d\right\}$$

Geometrical Progression

If a is the first term; l, the last term; r, the common ratio; n, the number of terms and s, the sum of n terms, —

$$l = ar^{n-1}$$

$$s = \frac{a(r^n - 1)}{r - 1}$$

$$s = \frac{a(1 - r^n)}{1 - r}$$

If n is infinity and r less than unity, —

$$s = \frac{a}{1 - r}$$

Permutations

If M denote the number of permutations of n things taken p at a time, —

$$M = n(n-1)(n-2) \ldots\ldots (n - p + 1)$$

Combinations

If M denote the number of combinations of n things taken p at a time, —

$$M = \frac{n(n-1)(n-2) \ldots\ldots (n - p + 1)}{\underline{|p}}$$

$$M = \frac{\underline{|n}}{\underline{|p}\;\underline{|n-p}}$$

ALGEBRA (Continued)

Approximations

If a and b are small quantities, the following relations are approximately true, —

$$(1 \pm a)^m = 1 \pm ma$$
$$(1 \pm a)^m(1 \pm b)^n = 1 \pm ma \pm nb$$

If n is nearly equal to m,

$$\sqrt{nm} = \frac{n+m}{2}, \text{ approximately.}$$

If θ is a very small angle expressed in radians, —

$$\frac{\sin\theta}{\theta} = 1 \text{ and } \frac{\tan\theta}{\theta} = 1, \text{ approximately.}$$

Series

Binomial

$$(x+y)^n = x^n + nx^{n-1}y + \frac{n(n-1)}{\underline{|2}}x^{n-2}y^2 + \ldots.$$
$$\frac{n(n-1)\ldots(n-m+1)}{\underline{|m}}x^{n-m}y^m + \ldots \qquad (y^2 < x^2)$$
$$(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)x^2}{\underline{|2}} \pm \frac{n(n-1)(n-2)x^3}{\underline{|3}} + \ldots \text{etc.} \qquad (x^2 < 1)$$
$$(1 \pm x)^{-n} = 1 \;\; n \mp x + \frac{n(n+1)x^2}{\underline{|2}} \mp \frac{n(n-1)(n-2)x^3}{\underline{|3}} + \ldots \text{etc.} \qquad (x^2 < 1)$$
$$(1 \pm x)^{-1} = 1 \mp x + x^2 \mp x^3 + x^4 \mp x^5 + \ldots \qquad (x^2 < 1)$$
$$(1 \pm x)^{-2} = 1 \mp 2x + 3x^2 \mp 4x^3 + 5x^4 \mp 6x^5 + \ldots \qquad (x^2 < 1)$$

Taylor's Series

$$f(x+h) = f(x) + hf'(x) + \frac{h^2}{\underline{|2}}f''(x) + \frac{h^3}{\underline{|3}}f'''(x) + \ldots$$

Maclaurin's Series

$$f(x) = f(o) + \frac{x}{1}f'(o) + \frac{x^2}{\underline{|2}}f''(o) + \frac{x^3}{\underline{|3}}f'''(o) + \ldots$$

Exponential

$$e = 1 + \frac{1}{1} + \frac{1}{\underline{|2}} + \frac{1}{\underline{|3}} + \frac{1}{\underline{|4}} + \ldots$$
$$e^x = 1 + x + \frac{x^2}{\underline{|2}} + \frac{x^3}{\underline{|3}} + \frac{x^4}{\underline{|4}} + \ldots$$
$$a^x = 1 + x\log a + \frac{(x\log a)^2}{\underline{|2}} + \frac{(x\log a)^3}{\underline{|3}} + \ldots$$

ALGEBRA (Continued)

Logarithmic

$$\log_e x = \frac{x-1}{x} + \frac{1}{2}\left(\frac{x-1}{x}\right)^2 + \frac{1}{3}\left(\frac{x-1}{x}\right)^3 + \dots \qquad (x > \tfrac{1}{2})$$

$$\log_e x = (x-1) - \tfrac{1}{2}(x-1)^2 + \tfrac{1}{3}(x-1)^3 - \dots \qquad (2 > x > 0)$$

$$\log_e x = 2\left[\frac{x-1}{x+1} + \frac{1}{3}\left(\frac{x-1}{x+1}\right)^3 + \frac{1}{5}\left(\frac{x-1}{x+1}\right)^5 + \dots\right] \qquad (x > 0)$$

$$\log_e(1+x) = x - \tfrac{1}{2}x^2 + \tfrac{1}{3}x^3 - \tfrac{1}{4}x^4 + \dots$$

$$\log_e(n+1) - \log_e(n-1) = 2\left[\frac{1}{n} + \frac{1}{3n^3} + \frac{1}{5n^5} + \dots\right]$$

$$\log_{10}(n+1) - \log_{10}{}^{n} = \frac{k}{n} + \frac{k}{2n^2} + \frac{k}{3n^3} + \dots \quad \text{where } k = .4343\dots$$

Trigonometric

$$\sin x = x - \frac{x^3}{\underline{|3}} + \frac{x^5}{\underline{|5}} - \frac{x^7}{\underline{|7}} + \dots$$

$$\cos x = 1 - \frac{x^2}{\underline{|2}} + \frac{x^4}{\underline{|4}} - \frac{x^6}{\underline{|6}} + \dots$$

$$\tan x = x + \frac{x^3}{3} + \frac{2x^5}{15} + \frac{17x^7}{315} + \frac{62x^9}{2835} + \dots \qquad \left(x^2 < \frac{\pi^2}{4}\right)$$

$$\sin^{-1}x = x + \frac{x^3}{6} + \frac{1}{2}\cdot\frac{3}{4}\cdot\frac{x^5}{\underline{|5}} + \frac{1}{2}\cdot\frac{3}{4}\cdot\frac{5}{6}\cdot\frac{x^7}{\underline{|7}} + \dots \qquad (x^2 < 1)$$

$$\tan^{-1}x = x - \frac{1}{3}x^3 + \frac{1}{5}x^5 - \frac{1}{7}x^7 + \dots \qquad (x^2 < 1)$$

$$= \frac{\pi}{2} - \frac{1}{x} + \frac{1}{3x^3} - \frac{1}{5x^5} + \dots \qquad (x^2 > 1)$$

MENSURATION FORMULÆ

Plain Figures Bounded by Straight Lines

The **area of a triangle** whose base is b and altitude h

$$=\frac{hb}{2}.$$

The area of a **triangle** with angles A, B, and C and sides opposite a, b, and c, respectively

$$=1/2ab \sin C.$$

or $$=\sqrt{s(s-a)(s-b)(s-c)},$$

where $s=1/2(a+b+c)$.

A **rectangle** with sides a and b has an area $=ab$.

The area of a **parallelogram** with side b and the perpendicular distance to the parallel side h

$$=bh.$$

The area of a **parallelogram** with sides a and b and the included angle θ

$$=ab \sin \theta.$$

The area of a **rhombus** with diagonals c and d,

$$=\tfrac{1}{2}cd.$$

The area of any **quadrilateral** with diagonals a and b and the angle between them θ

$$=\tfrac{1}{2}ab \sin \theta.$$

The area of a **regular polygon** with n sides, each of length l,

$$=\tfrac{1}{4}nl^2 \cot \frac{180}{n}.$$

For a regular polygon of n sides, each side of length l, the radius of the **inscribed circle**,

$$=\frac{l}{2}\cot \frac{180}{n}.$$

The radius of the **circumscribed circle**,

$$=\frac{l}{2}\operatorname{cosec} \frac{180}{n}.$$

Area, Radius of Inscribed and Circumscribed Circles for Regular Polygons

l = length of one side.

Name.	Number of sides.	Area.	Radius of inscribed. circle.	Radius of circumscribed circle.
Triangle, equilateral	3	$0.43301l^2$	$0.28867l$	$0.57735l$
Square	4	$1.00000l^2$	$0.50000l$	$0.70710l$
Pentagon	5	$1.72048l^2$	$0.68819l$	$0.85065l$
Hexagon	6	$2.59808l^2$	$0.86602l$	$1.0000l$
Heptagon	7	$3.63391l^2$	$1.0383l$	$1.1523l$
Octagon	8	$4.82843l^2$	$1.2071l$	$1.3065l$
Nonagon	9	$6.18182l^2$	$1.3737l$	$1.4619l$
Decagon	10	$7.69421l^2$	$1.5388l$	$1.6180l$
Undecagon	11	$9.36564l^2$	$1.7028l$	$1.7747l$
Dodecagon	12	$11.19615l^2$	$1.8660l$	$1.9318l$

Radius of circle inscribed in any triangle, whose sides are a, b, and c, where $s=\frac{1}{2}(a+b+c)$

$$=\frac{\sqrt{s(s-a)(s-b)(s-c)}}{s}.$$

The radius of the circumscribed circle

$$=\frac{abc}{4\sqrt{s(s-a)(s-b)(s-c)}}.$$

The perimeter of a polygon inscribed in a circle of radius r, where n is the number of sides,

$$=2nr\sin\frac{\pi}{n}.$$

The area of the inscribed polygon,

$$=\frac{1}{2}nr^2\sin\frac{2\pi}{n}.$$

The perimeter of a polygon circumscribed about a circle of radius r, number of sides n

$$=2nr\tan\frac{\pi}{n}.$$

The area of the circumscribed polygon

$$=nr^2\tan\frac{\pi}{n}.$$

Plane Figures Bounded by Curved Lines

The **circumference of a circle** whose radius is r and diameter $d(d=2r)$

$$=2\pi r=\pi d.$$

The **area of a circle**

$$=\pi r^2=\tfrac{1}{4}\pi d^2=.7854d^2.$$

The **length of an arc** of a circle for an arc of θ degrees

$$=\frac{\pi r\theta}{180}.$$

NOTE.—In this and following similar formulæ r denotes the radius of the circle, (OC, Fig. 1).

For an arc of θ radians the length

$$=r\theta.$$

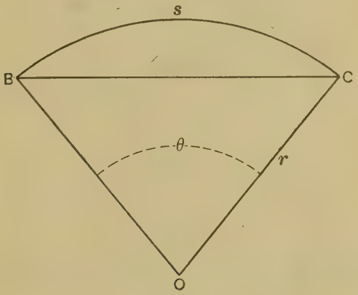

FIG. 1.

The **length of a chord** subtending an angle θ

$$=2r\sin\tfrac{1}{2}\theta.$$

The **area of a sector** where θ is the angle between the radii in degrees

$$=\frac{\pi r^2\theta}{360}.$$

If s is the length of the arc, the area of the sector

$$=\frac{sr}{2}.$$

The **area of a segment** where θ is the angle between the two radii in degrees

$$=\frac{\pi r^2\theta}{360}-\frac{r^2\sin\theta}{2}.$$

If θ is in radians the area

$$=\tfrac{1}{2}r^2(\theta-\sin\theta).$$

The **area of the ring** between two circles of radius r_1 and r_2, one of which encloses the other,

$$=\pi(r_1+r_2)(r_1-r_2).$$

The two cricles are not necessarily concentric.

Area of the sector of an annulus. (Fig. 2.)—If angle $GOH=\theta$ and the lines GO and $JO=r_1$ and r_2 respectively, the area $GHIJ$

$$=\tfrac{1}{2}\theta(r_1+r_2)(r_1-r_2).$$

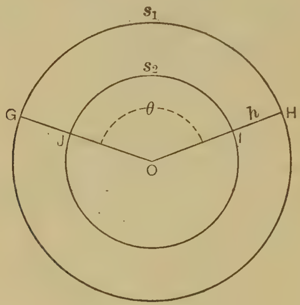

FIG. 2.

If $s_1=$ the length of the arc GH and $s_2=$ the arc JI and $h=HI=r_1-r_2$, the area $GHIJ$

$$=\tfrac{1}{2}h(s_1+s_2).$$

The **circumference of an ellipse** whose semiaxes are a and b

$$=2\pi\sqrt{\frac{a^2+b^2}{2}}, \text{ approximately.}$$

The **area of an ellipse**

$$=\pi ab.$$

The length of the **arc of a parabola,** as arc SPQ in Fig. 3, where $x=PR$, and $y=QR$

$$=2\sqrt{y^2+\frac{4x^2}{3}}.$$

The **area of the section of the parabola** $PQRS$,

$$=\frac{4}{3}xy.$$

Solids Bounded by Planes

The **lateral area of a regular prism** = perimeter of a right section × the length.

The **volume of a regular prism** = area of base × the altitude.

The **lateral area of a regular pyramid**, slant height l and length of one side of base a,

$$= \tfrac{1}{2}nal.$$

The **volume of a pyramid** = $\frac{1}{3}$ area of base × altitude.

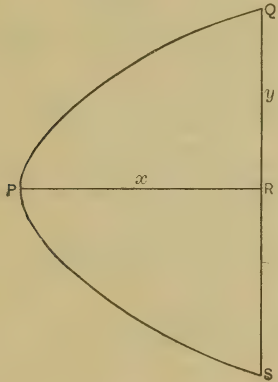

Fig. 3.

Surface and Volume of Regular Polyhedra

Surface and volume of regular polyhedra in terms of the length of one edge l.

Name.	Nature of surface.	Surface.	Volume.
Tetrahedron . . .	4 equilateral triangles	$1.73205l^2$	$0.11785l^3$
Hexahedron or cube	6 squares	$6.00000l^2$	$1.00000l^3$
Octahedron. . . .	8 equilateral triangles	$3.46410l^2$	$0.47140l^3$
Dodecahedron .	10 pentagons.	$20.64578l^2$	$7.66312l^3$
Icosahedron . . .	20 equilat.-triangles.	$8.66025l^2$	$2.18170l^3$

Solids Bounded by Curved Surfaces

The **surface of a sphere** of radius r and diameter $d(=2r)$

$$= 4\pi r^2 = \pi d^2 = 12.57r^2.$$

The **volume of a sphere**

$$= \tfrac{4}{3}\pi r^3 = \tfrac{1}{6}\pi d^3 = 4.189r^3.$$

The **area of a lune** on the surface of a sphere of radius r, included between two great circles whose inclination is θ radians

$$=2r^2\theta.$$

The **area of a spherical triangle** whose angles are A, B, and C (radians) on a sphere of radius r

$$=(A+B+C-\pi)r^2.$$

The **area of a spherical polygon** of n sides where θ is the sum of its angles in radians

$$=[\theta-(n-2)\pi]r^2.$$

The area of the curved surface of a **spherical segment** of height h, radius of sphere r

$$=2\pi rh.$$

The **volume of a spherical segment,** data as above

$$=\tfrac{1}{3}\pi h^2(3r-h).$$

If a = radius of the base of the segment, the volume

$$=\tfrac{1}{6}\pi h(h^2+3a^2).$$

The **curved surface of a right cylinder** where r = the radius of the base and h, the altitude,

$$=2\pi rh.$$

The **volume of a cylinder,** data as above,

$$=\pi r^2h.$$

The **curved surface of a right cone** whose altitude is h and radius of base r

$$=\pi r\sqrt{r^2+h^2}.$$

The **volume of a cone,** data as above,

$$=\frac{\pi}{3}r^2h=1.047r^2h.$$

The curved surface of the frustum of a right cone, radius of base r, of top r^2 and altitude h,

$$=\pi(r_1+r_2)\sqrt{h^2+r^2}.$$

The **volume of the frustum of a cone,** data as above,

$$=\pi\left(\frac{r_1{}^2+r_2{}^2}{2}\right)\frac{h}{3}.$$

The **oblate spheroid** is formed by the rotation of an ellipse about its minor axis. If a and b are the major and minor semi-axes respectively, and e the eccentricity, the surface

$$=2\pi a^2+\pi\frac{b^2}{c}\log_e\frac{1+e}{1-e},$$

and volume $=\tfrac{4}{3}\pi a^2b.$

The **prolate spheroid** is formed by the rotation of an ellipse about its major axis ($2a$), data as above.

Surface $=2\pi b^2+2\pi\frac{ab}{e}\sin^{-1}e$,

volume $=4/3\pi ab^2$.

TRIGONOMETRIC FUNCTIONS IN A RIGHT-ANGLED TRIANGLE

If A, B, and C are the vertices (C the right angle), and a, b, and h the sides opposite respectively,

$\sin A = \frac{a}{h}$, $\cos A = \frac{b}{h}$,

$\tan A = \frac{a}{b}$, $\cot A = \frac{b}{a}$,

$\text{secant } A = \frac{h}{b}$, $\text{cosec } A = \frac{h}{a}$.

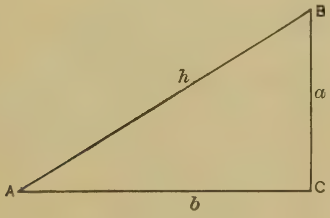

FIG. 4.

SIGNS AND LIMITS OF VALUE ASSUMED BY THE FUNCTIONS

Funtion.	Quadrant I.		Quadrant II.		Quadrant III.		Quadrant IV.	
	Sign.	Value.	Sign.	Value.	Sign.	Value.	Sign.	Value.
sin	+	0 to 1	+	1 to 0	−	0 to 1	−	1 to 0
cos	+	1 to 0	−	0 to 1	−	1 to 0	+	0 to 1
tan	+	0 to ∞	−	∞ to 0	+	0 to ∞	−	∞ to 0
cot	+	∞ to 0	−	0 to ∞	+	∞ to 0	−	0 to ∞
sec	+	1 to ∞	−	∞ to 1	−	1 to ∞	+	∞ to 1
cosec	+	∞ to 1	+	1 to ∞	−	∞ to 1	−	1 to ∞

VALUE OF THE FUNCTIONS OF VARIOUS ANGLES

	0°	30°	45°	60°	90°	180°	270°
sin......	0	1/2	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}\sqrt{3}$	1	0	−1
cos......	1	$\frac{1}{2}\sqrt{3}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0	−1	0
tan......	0	$1/\sqrt{3}$	1	$\sqrt{3}$	∞	0	∞
cot......	∞	$\sqrt{3}$	1	$\frac{1}{\sqrt{3}}$	0	∞	0

RELATIONS OF THE FUNCTIONS

$$\sin x = \frac{1}{\operatorname{cosec} x}. \qquad \operatorname{cosec} x = \frac{1}{\sin x}.$$

$$\cos x = \frac{1}{\sec x}. \qquad \sec x = \frac{1}{\cos x}.$$

$$\tan x = \frac{1}{\cot x} = \frac{\sin x}{\cos x}.$$

$$\cot x = \frac{1}{\tan x} = \frac{\cos x}{\sin x}.$$

$$\sin x = \sqrt{1-\cos^2 x}. \qquad \cos x = \sqrt{1-\sin^2 x}.$$

$$\tan x = \sqrt{\sec^2-1}. \qquad \sec x = \sqrt{\tan^2+1}.$$

$$\cot x = \sqrt{\operatorname{cosec}^2 x-1}. \qquad \operatorname{cosec} x = \sqrt{\cot^2 x+1}.$$

$$\sin x = \cos(90-x) = (\sin 180-x).$$

$$\cos x = \sin(90-x) = -\cos(180-x).$$

$$\tan x = \cot(90-x) = -\tan(180-x).$$

$$\cot x = \tan(90-x) = -\cot(180-x).$$

FUNCTIONS OF SUMS OF ANGLES

$$\sin(x+y) = \sin x \cos y + \cos x \sin y.$$

$$\sin(x-y) = \sin x \cos y - \cos x \sin y.$$

$$\cos(x+y) = \cos x \cos y - \sin x \sin y.$$

$$\cos(x-y) = \cos x \cos y + \sin x \sin y.$$

$$\tan(x+y) = \frac{\tan x + \tan y}{1 - \tan x \tan y}.$$

$$\tan(x-y) = \frac{\tan x - \tan y}{1 + \tan x \tan y}.$$

FUNCTIONS OF MULTIPLE ANGLES

$\sin\ 2x = 2 \sin x \cos x.$

$\cos\ 2x = \cos^2 x - \sin^2 x = 2 \cos^2 x - 1 = 1 - 2 \sin^2 x.$

$\sin\ 3x = 3 \sin x - 4 \sin^3 x.$

$\cos\ 3x = 4 \cos^3 x - 3 \cos x.$

$$\tan\ 2x = \frac{2 \tan x}{1 - \tan^2 x}.$$

$$\tan\ 3x = \frac{3 \tan x - \tan^3 x}{1 - 3 \tan^2 x}.$$

$$\sin\ \tfrac{1}{2}x = \pm\sqrt{\frac{1 - \cos x}{2}}.$$

$$\cos\ \tfrac{1}{2}x = \pm\sqrt{\frac{1 + \cos x}{2}}.$$

$$\tan\ \tfrac{1}{2}x = \pm\sqrt{\frac{1 - \cos x}{1 + \cos x}}.$$

RELATIONS BETWEEN SIDES AND ANGLES OF ANY TRIANGLE

In a triangle with angles A, B, and C and sides opposite a, b, and c respectively,

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}.$$

$$a^2 = b^2 + c^2 - 2bc \cos A.$$

$$a = b \cos C + c \cos B.$$

$$\cos\ A = \frac{b^2 + c^2 - a^2}{2bc}.$$

$$\tan\ \frac{A - B}{2} = \frac{a - b}{a + b} \cot \frac{C}{2}.$$

$$\sin\ A = \frac{2}{bc}\sqrt{s(s-a)(s-b)(s-c)},$$

where $s = \tfrac{1}{2}(a + b + c).$

$$\sin\ \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}.$$

$$\cos\ \frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}.$$

$$\tan\ \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}.$$

CALCULUS

Derivatives

$$d\,ax = a\,dx$$

$$d\,uv = \left(u\frac{dv}{dx} + v\frac{du}{dx}\right)dx$$

$$d\,\frac{u}{v} = \left(\frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}\right)dx$$

$$dx^n = n\,x^{n-1}dx$$

$$d\,f(u) = d\frac{f(u)}{du} \cdot \frac{du}{dx} \cdot dx$$

$$d\,e^x = e^x dx$$

$$d\,e^{ax} = a\,e^{ax}dx$$

$$d\log_e x = \frac{1}{x}dx$$

$$d\,x^x = x^x(1 + \log_e x)$$

$$d\sin x = \cos x\,dx$$

$$d\cos x = -\sin x\,dx$$

$$d\tan x = \sec^2 x\,dx$$

$$d\cot x = -\csc^2 x\,dx$$

$$d\sec x = \tan x\sec x\,dx$$

$$d\csc x = -\cot x \cdot \csc x\,dx$$

$$d\sin^{-1}x = (1 - x^2)^{-\frac{1}{2}}dx$$

$$d\cos^{-1}x = -(1 - x^2)^{-\frac{1}{2}}dx$$

$$d\tan^{-1}x = (1 + x^2)^{-1}dx$$

$$d\cot^{-1}x = -(1 + x^2)^{-1}dx$$

$$d\sec^{-1}x = x^{-1}(x^2 - 1)^{-\frac{1}{2}}dx$$

$$d\csc^{-1}x = -x^{-1}(x^2 - 1)^{-\frac{1}{2}}dx$$

Integrals

$$\int x^n\,dx = \frac{x^{n+1}}{n+1} \qquad \text{except } n = -1$$

$$\int \frac{dx}{x} = \log x$$

$$\int e^x dx = e^x$$

$$\int e^{ax}dx = \frac{1}{a}e^{ax}$$

$$\int x\,e^{ax}dx = \frac{e^{ax}}{a^2}(ax - 1)$$

$$\int \log x\,dx = x\log x - x$$

$$\int u\,dv = uv - \int v\,du$$

Integrals (Continued)

$$\int (a + bx)^n dx = \frac{(a + bx)^{n+1}}{(n + 1)b}$$

$$\int (a^2 + x^2)^{-1} dx = \frac{1}{a} \tan^{-1} \frac{x}{a} = \frac{1}{a} \sin^{-1} \frac{x}{\sqrt{x^2 + a^2}}$$

$$\int (a^2 - x^2)^{-1} dx = \frac{1}{2a} \log \frac{a + x}{a - x}$$

$$\int (a^2 - x^2)^{-\frac{1}{2}} dx = \sin^{-1} \frac{x}{a} = -\cos^{-1} \frac{x}{a}$$

$$\int x(a^2 \pm x^2)^{-\frac{1}{2}} dx = \pm(a^2 \pm x^2)^{\frac{1}{2}}$$

$$\int \sin^2 x dx = -\tfrac{1}{2} \cos x \sin x + \tfrac{1}{2}x$$

$$\int \cos^2 x\, dx = \tfrac{1}{2} \sin x \cos x + \tfrac{1}{2}x$$

$$\int \sin x \cos x\, dx = \tfrac{1}{2} \sin^2 x$$

$$\int (\sin x \cos x)^{-1} dx = \log \tan x$$

$$\int \tan x dx = -\log \cos x$$

$$\int \tan^2 x\, dx = \tan x - x$$

$$\int \cot x\, dx = \log \sin x$$

$$\int \cot^2 x dx = -\cot x - x$$

$$\int \csc x dx = \log \tan \tfrac{1}{2}x$$

$$\int x \sin x\, dx = \sin x - x \cos x$$

$$\int x \cos x\, dx = \cos x + x \sin x$$

ANALYTICAL GEOMETRY

The distance between two points x_1, y_1, and x_2, y_2, — rectangular coördinates:

$$d = \pm \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

For polar coördinates and points r_1, θ_1, and r_2, θ_2:

$$d = \pm \sqrt{r_1^2 + r_2^2 - 2r_1r_2 \cos(\theta_1 - \theta_2)}$$

The area of a triangle whose vertices are x_1, y_1; x_2, y_2, and x_3, y_3:

$$A = \tfrac{1}{2}(x_1y_2 - x_2y_1 + x_2y_3 - x_3y_2 + x_3y_1 - x_1y_3)$$

For polar coördinates and vertices, r_1, θ_1; r_2, θ_2, and r_3, θ_3:

$$A = \tfrac{1}{2}\left\{ (r_1r_2 \sin(\theta_2 - \theta_1) + r_2r_3 \sin(\theta_3 - \theta_2) + r_3r_1 \sin(\theta_1 - \theta_3) \right\}$$

The equation of a straight line where m is the tangent of the angle of inclination and c, the distance of intersection with the axis from the origin:

$$y = mx + c$$

If a line of inclination m passes through the point x_1, y_1 its equation is:

$$y - y_1 = m(x - x_1)$$

The equation of a line through the points x_1, y_1, and x_2, y_2 is:

$$\frac{y - y_1}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1}$$

If the intercepts on the axes are a and b, the equation is:

$$\frac{x}{a} + \frac{y}{b} = 1$$

If the length of the perpendicular from the origin is p and its angle of inclination θ the equation is:

$$x \cos\theta + y \sin\theta = p$$

General equation of the straight line:

$$Ax + By + C = 0$$

The equation of a circle whose center is at a, b:

$$(x - a)^2 + (y - b)^2 = c^2$$

If the origin is at the center:

$$x^2 + y^2 = c^2$$

The polar equation of a circle with the origin on the circumference and its center at point c, α:

$$r = 2c \cos(\theta - \alpha).$$

If the origin is not on the circumference, the radius α and the center at a point l, α, the equation becomes:

$$a^2 = r^2 + l^2 - 2rl \cos(\theta - \alpha)$$

The equation of a parabola with the origin at the vertex, where p is the distance from the focus to the vertex:

$$y^2 = 4px$$

The polar equation where the pole is at the focus and l the semi-latus rectum is:

$$\frac{l}{r} = 1 - \cos\theta$$

If the pole is at the vertex and p as above:

$$r = \frac{4p \cos\theta}{\sin^2\theta}$$

The equation of the ellipse with the origin at the center and semi-axes a and b:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Polar equation where the pole is at the center:

$$r^2 = \frac{a^2b^2}{a^2 \sin^2\theta + b^2 \cos^2\theta}$$

The equation of the hyperbola with the origin at the center, semi-axes a and b:

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$$

Polar equation, pole at center:

$$r^2 = \frac{a^2b^2}{a^2 \sin^2\theta - b^2 \cos^2\theta}$$

EXPLANATION OF LOGARITHM TABLES

The logarithm of a number is the exponent of that power to which another number, the base, must be raised to give the number first named. The base commonly used is 10 and as most numbers are incommensurable powers of ten a common logarithm, in general, consists of an integer which is called the characteristic and an endless decimal, the mantissa.

It is to be observed that the common logarithms of all numbers expressed by the same figures in the same order with the decimal point in different positions have different characteristics but the same mantissa. To illustrate: — if the decimal point stand after the first figure of a number, counting from the left, the characteristic is 0; if after two figures, it is 1; if after three figures, it is 2, and so forth. If the decimal point stand before the

first significant figure the characteristic is -1, usually written $\bar{1}$; if there is one zero between the decimal point and the first significant figure it is $\bar{2}$ and so on. For example: $\log 256 = 2.40824$, $\log 2.56 = 0.40824$, $\log 0.256 = \bar{1}.40824$, $\log 0.00256 = \bar{3}.40824$. Inasmuch as the characteristic may be determined by inspection the mantissas only are given in tables of common logarithms.

To find the logarithm of a number.

For a number of four figures take out the tabular mantissa on a line with the first three figures of the number and under its third figure. The characteristic is determined as previously explained.

For a number of less than four figures supply zeros to make a four figure number and take the value of the mantissa from the tables as before. For example: $\log 2 = \log 2.000 = 0.30103$.

For a number of more than four figures take the tabular value of the mantissa for the first four figures; find the difference between this mantissa and the next greater tabular mantissa and multiply the difference so found by the remaining figures of the number as a decimal and add the product to the mantissa of the first four figures. For example: to find log 46.762.

$$\log 46.76 = 1.66987$$

Tabular difference between this mantissa and that for 4677 is .00010.

$$\begin{aligned} \therefore \log 46.762 &= 1.66987 + .2 \times .00010 \\ &= 1.66987 + .00002 \\ &= 1.66989 \end{aligned}$$

To find the number corresponding to a given logarithm.

If the mantissa is found exactly in the table, join the figure at the top which is directly above the given mantissa to the three figures on the line at the left and place the decimal point according to the characteristic of the logarithm. For example, $\log^{-1}$ (antilogarithm) $3.39967 = 2510$.

If the mantissa is not found exactly in the table it is necessary to interpolate. For example, $\log^{-1} 3.40028 = 2513. + \frac{9}{18} = 2513.5$.

The column of proportional parts at the right of each page of the table shows, under the heading of the various tabular differences, the parts of these differences which correspond to the digits from 1 to 9 in the fifth place. This makes it possible to take out a logarithm for a five figure number or to find an antilogarithm of the same number of significant figures with increased facility, usually by inspection.

The following formulæ express the relations on which the use of logarithms is based.

$$\log ab = \log a + \log b$$

$$\log \frac{a}{b} = \log a - \log b$$

$$\log a^n = n \times \log a$$

$$\log \sqrt[n]{a} = \frac{\log a}{n}$$

FIVE-PLACE LOGARITHMS

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts			
100	00 000	043	087	130	173	217	260	303	346	389		**44**	**43**	**42**
101	432	475	518	561	604	647	689	732	775	817	1	4,4	4,3	4,2
102	860	903	945	988	*030	*072	*115	*157	*199	*242	2	8,8	8,6	8,4
103	01 284	326	368	410	452	494	536	578	620	662	3	13,2	12,9	12,6
104	703	745	787	828	870	912	953	995	*036	*078	4	17,6	17,2	16,8
105	02 119	160	202	243	284	325	366	407	449	490	5	22,0	21,5	21,0
106	531	572	612	653	694	735	776	816	857	898	6	26,4	25,8	25,2
107	938	979	*019	*060	*100	*141	*181	*222	*262	*302	7	30,8	30,1	29,4
108	03 342	383	423	463	503	543	583	623	663	703	8	35,2	34,4	33,6
109	743	782	822	862	902	941	981	*021	*060	*100	9	39,6	38,7	37,8
110	04 139	179	218	258	297	336	376	415	454	493		**41**	**40**	**39**
111	532	571	610	650	689	727	766	805	844	883	1	4,1	4,0	3,9
112	922	961	999	*038	*077	*115	*154	*192	*231	*269	2	8,2	8,0	7,8
113	05 308	346	385	423	461	500	538	576	614	652	3	12,3	12,0	11,7
114	690	729	767	805	843	881	918	956	994	*032	4	16,4	16,0	15,6
115	06 070	108	145	183	221	258	296	333	371	408	5	20,5	20,0	19,5
116	446	483	521	558	595	633	670	707	744	781	6	24,6	24,0	23,4
117	819	856	893	930	967	*004	*041	*078	*115	*151	7	28,7	28,0	27,3
118	07 188	225	262	298	335	372	408	445	482	518	8	32,8	32,0	31,2
119	555	591	628	664	700	737	773	809	846	882	9	36,9	36,0	35,1
120	918	954	990	*027	*063	*099	*135	*171	*207	*243		**38**	**37**	**36**
121	08 279	314	350	386	422	458	493	529	565	600	1	3,8	3,7	3,6
122	636	672	707	743	778	814	849	884	920	955	2	7,6	7,4	7,2
123	991	*026	*061	*096	*132	*167	*202	*237	*272	*307	3	11,4	11,1	10,8
124	09 342	377	412	447	482	517	552	587	621	656	4	15,2	14,8	14,4
125	691	726	760	795	830	864	899	934	968	*003	5	19,0	18,5	18,0
126	10 037	072	106	140	175	209	243	278	312	346	6	22,8	22,2	21,6
127	380	415	449	483	517	551	585	619	653	687	7	26,6	25,9	25,2
128	721	755	789	823	857	890	924	958	992	*025	8	30,4	29,6	28,8
129	11 059	093	126	160	193	227	261	294	327	361	9	34,2	33,3	32,4
130	394	428	461	494	528	561	594	628	661	694		**35**	**34**	**33**
131	727	760	793	826	860	893	926	959	992	*024	1	3,5	3,4	3,3
132	12 057	090	123	156	189	222	254	287	320	352	2	7,0	6,8	6,6
133	385	418	450	483	516	548	581	613	646	678	3	10,5	10,2	9,9
134	710	743	775	808	840	872	905	937	969	*001	4	14,0	13,6	13,2
135	13 033	066	098	130	162	194	226	258	290	322	5	17,5	17,0	16,5
136	354	386	418	450	481	513	545	577	609	640	6	21,0	20,4	19,8
137	672	704	735	767	799	830	862	893	925	956	7	24,5	23,8	23,1
138	988	*019	*051	*082	*114	*145	*176	*208	*239	*270	8	28,0	27,2	26,4
139	14 301	333	364	395	426	457	489	520	551	582	9	31,5	30,6	29,7
140	613	644	675	706	737	768	799	829	860	891		**32**	**31**	**30**
141	922	953	983	*014	*045	*076	*106	*137	*168	*198	1	3,2	3,1	3,0
142	15 229	259	290	320	351	381	412	442	473	503	2	6,4	6,2	6,0
143	534	564	594	625	655	685	715	746	776	806	3	9,6	9,3	9,0
144	836	866	897	927	957	987	*017	*047	*077	*107	4	12,8	12,4	12,0
145	16 137	167	197	227	256	286	316	346	376	406	5	16,0	15,5	15,0
146	435	465	495	524	554	584	613	643	673	702	6	19,2	18,6	18,0
147	732	761	791	820	850	879	909	938	967	997	7	22,4	21,7	21,0
148	17 026	056	085	114	143	173	202	231	260	289	8	25,6	24,8	24,0
149	319	348	377	406	435	464	493	522	551	580	9	28,8	27,9	27,0
150	609	638	667	696	725	754	782	811	840	869				
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts			

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts		
150	17 609	638	667	696	725	754	782	811	840	869		**29**	**28**
151	898	926	955	984	*013	*041	*070	*099	*127	*156	1	2,9	2,8
152	18 184	213	241	270	298	327	355	384	412	441	2	5,8	5,6
153	469	498	526	554	583	611	639	667	696	724	3	8,7	8,4
154	752	780	808	837	865	893	921	949	977	*005	4	11,6	11,2
155	19 033	061	089	117	145	173	201	229	257	285	5	14,5	14,0
156	312	340	368	396	424	451	479	507	535	562	6	17,4	16,8
157	590	618	645	673	700	728	756	783	811	838	7	20,3	19,6
158	866	893	921	948	976	*003	*030	*058	*085	*112	8	23,2	22,4
159	20 140	167	194	222	249	276	303	330	358	385	9	26,1	25,2
160	412	439	466	493	520	548	575	602	629	656		**27**	**26**
161	683	710	737	763	790	817	844	871	898	925	1	2,7	2,6
162	952	978	*005	*032	*059	*085	*112	*139	*165	*192	2	5,4	5,2
163	21 219	245	272	299	325	352	378	405	431	458	3	8,1	7,8
164	484	511	537	564	590	617	643	669	696	722	4	10,8	10,4
165	748	775	801	827	854	880	906	932	958	985	5	13,5	13,0
166	22 011	037	063	089	115	141	167	194	220	246	6	16,2	15,6
167	272	298	324	350	376	401	427	453	479	505	7	18,9	18,2
168	531	557	583	608	634	660	686	712	737	763	8	21,6	20,8
169	789	814	840	866	891	917	943	968	994	*019	9	24,3	23,4
170	23 045	070	096	121	147	172	198	223	249	274		**25**	
171	300	325	350	376	401	426	452	477	502	528	1	2,5	
172	553	578	603	629	654	679	704	729	754	779	2	5,0	
173	805	830	855	880	905	930	955	980	*005	*030	3	7,5	
174	24 055	080	105	130	155	180	204	229	254	279	4	10,0	
175	304	329	353	378	403	428	452	477	502	527	5	12,5	
176	551	576	601	625	650	674	699	724	748	773	6	15,0	
177	797	822	846	871	895	920	944	969	993	*018	7	17,5	
178	25 042	066	091	115	139	164	188	212	237	261	8	20,0	
179	285	310	334	358	382	406	431	455	479	503	9	22,5	
180	527	551	575	600	624	648	672	696	720	744		**24**	**23**
181	768	792	816	840	864	888	912	935	959	983	1	2,4	2,3
182	26 007	031	055	079	102	126	150	174	198	221	2	4,8	4,6
183	245	269	293	316	340	364	387	411	435	458	3	7,2	6,9
184	482	505	529	553	576	600	623	647	670	694	4	9,6	9,2
185	717	741	764	788	811	834	858	881	905	928	5	12,0	11,5
186	951	975	998	*021	*045	*068	*091	*114	*138	*161	6	14,4	13,8
187	27 184	207	231	254	277	300	323	346	370	393	7	16,8	16,1
188	416	439	462	485	508	531	554	577	600	623	8	19,2	18,4
189	646	669	692	715	738	761	784	807	830	852	9	21,6	20,7
190	875	898	921	944	967	989	*012	*035	*058	*081		**22**	**21**
191	28 103	126	149	171	194	217	240	262	285	307	1	2,2	2,1
192	330	353	375	398	421	443	466	488	511	533	2	4,4	4,2
193	556	578	601	623	646	668	691	713	735	758	3	6,6	6,3
194	780	803	825	847	870	892	914	937	959	981	4	8,8	8,4
195	29 003	026	048	070	092	115	137	159	181	203	5	11,0	10,5
196	226	248	270	292	314	336	358	380	403	425	6	13,2	12,6
197	447	469	491	513	535	557	579	601	623	645	7	15,4	14,7
198	667	688	710	732	754	776	798	820	842	863	8	17,6	16,8
199	885	907	929	951	973	994	*016	*038	*060	*081	9	19,8	18,9
200	30 103	125	146	168	190	211	233	255	276	298			
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts		

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts		
200	30 103	125	146	168	190	211	233	255	276	298		**22**	**21**
201	320	341	363	384	406	428	449	471	492	514	1	2,2	2,1
202	535	557	578	600	621	643	664	685	707	728	2	4,4	4,2
203	750	771	792	814	835	856	878	899	920	942	3	6,6	6,3
204	963	984	*006	*027	*048	*069	*091	*112	*133	*154	4	8,8	8,4
205	31 175	197	218	239	260	281	302	323	345	366	5	11,0	10,5
206	387	408	429	450	471	492	513	543	555	576	6	13,2	12,6
207	597	618	639	660	681	702	723	744	765	785	7	15,4	14,7
208	806	827	848	869	890	911	931	952	973	994	8	17,6	16,8
209	32 015	035	056	077	098	118	139	160	181	201	9	19,8	18,9
210	222	243	263	284	305	325	346	366	387	408		**20**	
211	428	449	469	490	510	531	552	572	593	613	1	2,0	
212	634	654	675	695	715	736	756	777	797	818	2	4,0	
213	838	858	879	899	919	940	960	980	*001	*021	3	6,0	
214	33 041	062	082	102	122	143	163	183	203	224	4	8,0	
215	244	264	284	304	325	345	365	385	405	425	5	10,0	
216	445	465	486	506	526	546	566	586	606	626	6	12,0	
217	646	666	686	706	726	746	766	786	806	826	7	14,0	
218	846	866	885	905	925	945	965	985	*005	*025	8	16,0	
219	34 044	064	084	104	124	143	163	183	203	223	9	18,0	
220	242	262	282	301	321	341	361	380	400	420		**19**	
221	439	459	479	498	518	537	557	577	596	616	1	1,9	
222	635	655	674	694	713	733	753	772	792	811	2	3,8	
223	830	850	869	889	908	928	947	967	986	*005	3	5,7	
224	35 025	044	064	083	102	122	141	160	180	199	4	7,6	
225	218	238	257	276	295	315	334	353	372	392	5	9,5	
226	411	430	449	468	488	507	526	545	564	583	6	11,4	
227	603	622	641	660	679	698	717	736	755	774	7	13,3	
228	793	813	832	851	870	889	908	927	946	965	8	15,2	
229	984	*003	*021	*040	*059	*078	*097	*116	*135	*154	9	17,1	
230	36 173	192	211	229	248	267	286	305	324	342		**18**	
231	361	380	399	418	436	455	474	493	511	530	1	1,8	
232	549	568	586	605	624	642	661	680	698	717	2	3,6	
233	736	754	773	791	810	829	847	866	884	903	3	5,4	
234	922	940	959	977	996	*014	*033	*051	*070	*088	4	7,2	
235	37 107	125	144	162	181	199	218	236	254	273	5	9,0	
236	291	310	328	346	365	383	401	420	438	457	6	10,8	
237	475	493	511	530	548	566	585	603	621	639	7	12,6	
238	658	676	694	712	731	749	767	785	803	822	8	14,4	
239	840	858	876	894	912	931	949	967	985	*003	9	16,2	
240	38 021	039	057	075	093	112	130	148	166	184		**17**	
241	202	220	238	256	274	292	310	328	346	364	1	1,7	
242	382	399	417	435	453	471	489	507	525	543	2	3,4	
243	561	578	596	614	632	650	668	686	703	721	3	5,1	
244	739	757	775	792	810	828	846	863	881	899	4	6,8	
245	917	934	952	970	987	*005	*023	*041	*058	*076	5	8,5	
246	39 094	111	129	146	164	182	199	217	235	252	6	10,2	
247	270	287	305	322	340	358	375	393	410	428	7	11,9	
248	445	463	480	498	515	533	550	568	585	602	8	13,6	
249	620	637	655	672	690	707	724	742	759	777	9	15,3	
250	794	811	829	846	863	881	898	915	933	950			
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts		

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts	
250	39 794	811	829	846	863	881	898	915	933	950		**18**
251	967	985	*002	*019	*037	*054	*071	*088	*106	*123	1	1,8
252	40 140	157	175	192	209	226	243	261	278	295	2	3,6
253	312	329	346	364	381	398	415	432	449	466	3	5,4
254	483	500	518	535	552	569	586	603	620	637	4	7,2
255	654	671	688	705	722	739	756	773	790	807	5	9,0
256	824	841	858	875	892	909	926	943	960	976	6	10,8
257	993	*010	*027	*044	*061	*078	*095	*111	*128	*145	7	12,6
258	41 162	179	196	212	229	246	263	280	296	313	8	14,4
259	330	347	363	380	397	414	430	447	464	481	9	16,2
260	497	514	531	547	564	581	597	614	631	647		**17**
261	664	681	697	714	731	747	764	780	797	814	1	1,7
262	830	847	863	880	896	913	929	946	963	979	2	3,4
263	996	*012	*029	*045	*062	*078	*095	*111	*127	*144	3	5,1
264	42 160	177	193	210	226	243	259	275	292	308	4	6,8
265	325	341	357	374	390	406	423	439	455	472	5	8,5
266	488	504	521	537	553	570	586	602	619	635	6	10,2
267	651	667	684	700	716	732	749	765	781	797	7	11,9
268	813	830	846	862	878	894	911	927	943	959	8	13,6
269	975	991	*008	*024	*040	*056	*072	*088	*104	*120	9	15,3
270	43 136	152	169	185	201	217	233	249	265	281		**16**
271	297	313	329	345	361	377	393	409	425	441	1	1,6
272	457	473	489	505	521	537	553	569	584	600	2	3,2
273	616	632	648	664	680	696	712	727	743	759	3	4,8
274	775	791	807	823	838	854	870	886	902	917	4	6,4
275	933	949	965	981	996	*012	*028	*044	*059	*075	5	8,0
276	44 091	107	122	138	154	170	185	201	217	232	6	9,6
277	248	264	279	295	311	326	342	358	373	389	7	11,2
278	404	420	436	451	467	483	498	514	529	545	8	12,8
279	560	576	592	607	623	638	654	669	685	700	9	14,4
280	716	731	747	762	778	793	809	824	840	855		**15**
281	871	886	902	917	932	948	963	979	994	*010	1	1,5
282	45 025	040	056	071	086	102	117	133	148	163	2	3,0
283	179	194	209	225	240	255	271	286	301	317	3	4,5
284	332	347	362	378	393	408	423	439	454	469	4	6,0
285	484	500	515	530	545	561	576	591	606	621	5	7,5
286	637	652	667	682	697	712	728	743	758	773	6	9,0
287	788	803	818	834	849	864	879	894	909	924	7	10,5
288	939	954	969	984	*000	*015	*030	*045	*060	*075	8	12,0
289	46 090	105	120	135	150	165	180	195	210	225	9	13,5
290	240	255	270	285	300	315	330	345	359	374		**14**
291	389	404	419	434	449	464	479	494	509	523	1	1,4
292	538	553	568	583	598	613	627	642	657	672	2	2,8
293	687	702	716	731	746	761	776	790	805	820	3	4,2
294	835	850	864	879	894	909	923	938	953	967	4	5,6
295	982	997	*012	*026	*041	*056	*070	*085	*100	*114	5	7,0
296	47 129	144	159	173	188	202	217	232	246	261	6	8,4
297	276	290	305	319	334	349	363	378	392	407	7	9,8
298	422	436	451	465	480	494	509	524	538	553	8	11,2
299	567	582	596	611	625	640	654	669	683	698	9	12,6
300	712	727	741	756	770	784	799	813	828	842		
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts	

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9
300	47 712	727	741	756	770	784	799	813	828	842
301	857	871	885	900	914	929	943	958	972	986
302	48 001	015	029	044	058	073	087	101	116	130
303	144	159	173	187	202	216	230	244	259	273
304	287	302	316	330	344	359	373	387	401	416
305	430	444	458	473	487	501	515	530	544	558
306	572	586	601	615	629	643	657	671	686	700
307	714	728	742	756	770	785	799	813	827	841
308	855	869	883	897	911	926	940	954	968	982
309	996	*010	*024	*038	*052	*066	*080	*094	*108	*122
310	49 136	150	164	178	192	206	220	234	248	262
311	276	290	304	318	332	346	360	374	388	402
312	415	429	443	457	471	485	499	513	527	541
313	554	568	582	596	610	624	638	651	665	679
314	693	707	721	734	748	762	776	790	803	817
315	831	845	859	872	886	900	914	927	941	955
316	969	982	996	*010	*024	*037	*051	*065	*079	*092
317	50 106	120	133	147	161	174	188	202	215	229
318	243	256	270	284	297	311	325	338	352	365
319	379	393	406	420	433	447	461	474	488	501
320	515	529	542	556	569	583	596	610	623	637
321	651	664	678	691	705	718	732	745	759	772
322	786	799	813	826	840	853	866	880	893	907
323	920	934	947	961	974	987	*001	*014	*028	*041
324	51 055	068	081	095	108	121	135	148	162	175
325	188	202	215	228	242	255	268	282	295	308
326	322	335	348	362	375	388	402	415	428	441
327	455	468	481	495	508	521	534	548	561	574
328	587	601	614	627	640	654	667	680	693	706
329	720	733	746	759	772	786	799	812	825	838
330	851	865	878	891	904	917	930	943	957	970
331	983	996	*009	*022	*035	*048	*061	*075	*088	*101
332	52 114	127	140	153	166	179	192	205	218	231
333	244	257	270	284	297	310	323	336	349	362
334	375	388	401	414	427	440	453	466	479	492
335	504	517	530	543	556	569	582	595	608	621
336	634	647	660	673	686	699	711	724	737	750
337	763	776	789	802	815	827	840	853	866	879
338	892	905	917	930	943	956	969	982	994	*007
339	53 020	033	046	058	071	084	097	110	122	135
340	148	161	173	186	199	212	224	237	250	263
341	275	288	301	314	326	339	352	364	377	390
342	403	415	428	441	453	466	479	491	504	517
343	529	542	555	567	580	593	605	618	631	643
344	656	668	681	694	706	719	732	744	757	769
345	782	794	807	820	832	845	857	870	882	895
346	908	920	933	945	958	970	983	995	*008	*020
347	54 033	045	058	070	083	095	108	120	133	145
348	158	170	183	195	208	220	233	245	258	270
349	283	295	307	320	332	345	357	370	382	394
350	407	419	432	444	456	469	481	494	506	518
N.	0	1	2	3	4	5	6	7	8	9

Proportional parts

	15
1	1,5
2	3,0
3	4,5
4	6,0
5	7,5
6	9,0
7	10,5
8	12,0
9	13,5

	14
1	1,4
2	2,8
3	4,2
4	5,6
5	7,0
6	8,4
7	9,8
8	11,2
9	12,6

	13
1	1,3
2	2,6
3	3,9
4	5,2
5	6,5
6	7,8
7	9,1
8	10,4
9	11,7

	12
1	1,2
2	2,4
3	3,6
4	4,8
5	6,0
6	7,2
7	8,4
8	9,6
9	10,8

Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9
350	54 407	419	432	444	456	469	481	494	506	518
351	531	543	555	568	580	593	605	617	630	642
352	654	667	679	691	704	716	728	741	753	765
353	777	790	802	814	827	839	851	864	876	888
354	900	913	925	937	949	962	974	986	998	*011
355	55 023	035	047	060	072	084	096	108	121	133
356	145	157	169	182	194	206	218	230	242	255
357	267	279	291	303	315	328	340	352	364	376
358	388	400	413	425	437	449	461	473	485	497
359	509	522	534	546	558	570	582	594	606	618
360	630	642	654	666	678	691	703	715	727	739
361	751	763	775	787	799	811	823	835	847	859
362	871	883	895	907	919	931	943	955	967	979
363	991	*003	*015	*027	*038	*050	*062	*074	*086	*098
364	56 110	122	134	146	158	170	182	194	205	217
365	229	241	253	265	277	289	301	312	324	336
366	348	360	372	384	396	407	419	431	443	455
367	467	478	490	502	514	526	538	549	561	573
368	585	597	608	620	632	644	656	667	679	691
369	703	714	726	738	750	761	773	785	797	808
370	820	832	844	855	867	879	891	902	914	926
371	937	949	961	972	984	996	*008	*019	*031	*043
372	57 054	066	078	089	101	113	124	136	148	159
373	171	183	194	206	217	229	241	252	264	276
374	287	299	310	322	334	345	357	368	380	392
375	403	415	426	438	449	461	473	484	496	507
376	519	530	542	553	565	576	588	600	611	623
377	634	646	657	669	680	692	703	715	726	738
378	749	761	772	784	795	807	818	830	841	852
379	864	875	887	898	910	921	933	944	955	967
380	978	990	*001	*013	*024	*035	*047	*058	*070	*081
381	58 092	104	115	127	138	149	161	172	184	195
382	206	218	229	240	252	263	274	286	297	309
383	320	331	343	354	365	377	388	399	410	422
384	433	444	456	467	478	490	501	512	524	535
385	546	557	569	580	591	602	614	625	636	647
386	659	670	681	692	704	715	726	737	749	760
387	771	782	794	805	816	827	838	850	861	872
388	883	894	906	917	928	939	950	961	973	984
389	995	*006	*017	*028	*040	*051	*062	*073	*084	*095
390	59 106	118	129	140	151	162	173	184	195	207
391	218	229	240	251	262	273	284	295	306	318
392	329	340	351	362	373	384	395	406	417	428
393	439	450	461	472	483	494	506	517	528	539
394	550	561	572	583	594	605	616	627	638	649
395	660	671	682	693	704	715	726	737	748	759
396	770	780	791	802	813	824	835	846	857	868
397	879	890	901	912	923	934	945	956	966	977
398	988	999	*010	*021	*032	*043	*054	*065	*076	*086
399	60 097	108	119	130	141	152	163	173	184	195
400	206	217	228	239	249	260	271	282	293	304
N.	0	1	2	3	4	5	6	7	8	9

Proportional parts

	13	**12**	**11**	**10**
1	1,3	1,2	1,1	1,0
2	2,6	2,4	2,2	2,0
3	3,9	3,6	3,3	3,0
4	5,2	4,8	4,4	4,0
5	6,5	6,0	5,5	5,0
6	7,8	7,2	6,6	6,0
7	9,1	8,4	7,7	7,0
8	10,4	9,6	8,8	8,0
9	11,7	10,8	9,9	9,0

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts
400	60 206	217	228	239	249	260	271	282	293	304	
401	314	325	336	347	358	369	379	390	401	412	
402	423	433	444	455	466	477	487	498	509	520	
403	531	541	552	563	574	584	595	606	617	627	
404	638	649	660	670	681	692	703	713	724	735	
405	746	756	767	778	788	799	810	821	831	842	
406	853	863	874	885	895	906	917	927	938	949	
407	959	970	981	991	*002	*013	*023	*034	*045	*055	**11**
408	61 066	077	087	098	109	119	130	140	151	162	1 | 1,1
409	172	183	194	204	215	225	236	247	257	268	2 | 2,2
											3 | 3,3
410	278	289	300	310	321	331	342	352	363	374	4 | 4,4
411	384	395	405	416	426	437	448	458	469	479	5 | 5,5
412	490	500	511	521	532	542	553	563	574	584	6 | 6,6
413	595	606	616	627	637	648	658	669	679	690	7 | 7,7
414	700	711	721	731	742	752	763	773	784	794	8 | 8,8
415	805	815	826	836	847	857	868	878	888	899	9 | 9,9
416	909	920	930	941	951	962	972	982	996	*003	
417	62 014	024	034	045	055	066	076	086	097	107	
418	118	128	138	149	159	170	180	190	201	211	
419	221	232	242	252	263	273	284	294	304	315	
420	325	335	346	356	366	377	387	397	408	418	**10**
421	428	439	449	459	469	480	490	500	511	521	1 | 1,0
422	531	542	552	562	572	583	593	603	613	624	2 | 2,0
423	634	644	655	665	675	685	696	706	716	726	3 | 3,0
424	737	747	757	767	778	788	798	808	818	829	4 | 4,0
425	839	849	859	870	880	890	900	910	921	931	5 | 5,0
426	941	951	961	972	982	992	*002	*012	*022	*033	6 | 6,0
427	63 043	053	063	073	083	094	104	114	124	134	7 | 7,0
428	144	155	165	175	185	195	205	215	225	236	8 | 8,0
429	246	256	266	276	286	296	306	317	327	337	9 | 9,0
430	347	357	367	377	387	397	407	417	428	438	
431	448	458	468	478	488	498	508	518	528	538	
432	548	558	568	579	589	599	609	619	629	639	
433	649	659	669	679	689	699	709	719	729	739	
434	749	759	769	779	789	799	809	819	829	839	
435	849	859	869	879	889	899	909	919	929	939	**9**
436	949	959	969	979	988	998	*008	*018	*028	*038	1 | 0,9
437	64 048	058	068	078	088	098	108	118	128	137	2 | 1,8
438	147	157	167	177	187	197	207	217	227	237	3 | 2,7
439	246	256	266	276	286	296	306	316	326	335	4 | 3,6
											5 | 4,5
440	345	355	365	375	385	395	404	414	424	434	6 | 5,4
441	444	454	464	473	483	493	503	513	523	532	7 | 6,3
442	542	552	562	572	582	591	601	611	621	631	8 | 7,2
443	640	650	660	670	680	689	699	709	719	729	9 | 8,1
444	738	748	758	768	777	787	797	807	816	826	
445	836	846	856	865	875	885	895	904	914	924	
446	933	943	953	963	972	982	992	*002	*011	*021	
447	65 031	040	050	060	070	079	089	099	108	118	
448	128	137	147	157	167	176	186	196	205	215	
449	225	234	244	254	263	273	283	292	302	312	
450	321	331	341	350	360	369	379	389	398	408	
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9
450	65 321	331	341	350	360	369	379	389	398	408
451	418	427	437	447	456	466	475	485	495	504
452	514	523	533	543	552	562	571	581	591	600
453	610	619	629	639	648	658	667	677	686	696
454	706	715	725	734	744	753	763	772	782	792
455	801	811	820	830	839	849	858	868	877	887
456	896	906	916	925	935	944	954	963	973	982
457	992	*001	*011	*020	*030	*039	*049	*058	*068	*077
458	66 087	096	106	115	124	134	143	153	162	172
459	181	191	200	210	219	229	238	247	257	266
460	276	285	295	304	314	323	332	342	351	361
461	370	380	389	398	408	417	427	436	445	455
462	464	474	483	492	502	511	521	530	539	549
463	558	567	577	586	596	605	614	624	633	642
464	652	661	671	680	689	699	708	717	727	736
465	745	755	764	773	783	792	801	811	820	829
466	839	848	857	867	876	885	894	904	913	922
467	932	941	950	960	969	978	987	997	*006	*015
468	67 025	034	043	052	062	071	080	089	099	108
469	117	127	136	145	154	164	173	182	191	201
470	210	219	228	237	247	256	265	274	284	293
471	302	311	321	330	339	348	357	367	376	385
472	394	403	413	422	431	440	449	459	468	477
473	486	495	504	514	523	532	541	550	560	569
474	578	587	596	605	614	624	633	642	651	660
475	669	679	688	697	706	715	724	733	742	752
476	761	770	779	788	797	806	815	825	834	843
477	852	861	870	879	888	897	906	916	925	934
478	943	952	961	970	979	988	997	*006	*015	*024
479	68 034	043	052	061	070	079	088	097	106	115
480	124	133	142	151	160	169	178	187	196	205
481	215	224	233	242	251	260	269	278	287	296
482	305	314	323	332	341	350	359	368	377	386
483	395	404	413	422	431	440	449	458	467	476
484	485	494	502	511	520	529	538	547	556	565
485	574	583	592	601	610	619	628	637	646	655
486	664	673	681	690	699	708	717	726	735	744
487	753	762	771	780	789	797	806	815	824	833
488	842	851	860	869	878	886	895	904	913	922
489	931	940	949	958	966	975	984	993	*002	*011
490	69 020	028	037	046	055	064	073	082	090	099
491	108	117	126	135	144	152	161	170	179	188
492	197	205	214	223	232	241	249	258	267	276
493	285	294	302	311	320	329	338	346	355	364
494	373	381	390	399	408	417	425	434	443	452
495	461	469	478	487	496	504	513	522	531	539
496	548	557	566	574	583	592	601	609	618	627
497	636	644	653	662	671	679	688	697	705	714
498	723	732	740	749	758	767	775	784	793	801
499	810	819	827	836	845	854	862	871	880	888
500	897	906	914	923	932	940	949	958	966	975
N.	0	1	2	3	4	5	6	7	8	9

Proportional parts

	10
1	1,0
2	2,0
3	3,0
4	4,0
5	5,0
6	6,0
7	7,0
8	8,0
9	9,0

	9
1	0,9
2	1,8
3	2,7
4	3,6
5	4,5
6	5,4
7	6,3
8	7,2
9	8,1

	8
1	0,8
2	1,6
3	2,4
4	3,2
5	4,0
6	4,8
7	5,6
8	6,4
9	7,2

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9
500	69 897	906	914	923	932	940	949	958	966	975
501	984	992	*001	*010	*018	*027	*036	*044	*053	*062
502	70 070	079	088	096	105	114	122	131	140	148
503	157	165	174	183	191	200	209	217	226	234
504	243	252	260	269	278	286	295	303	312	321
505	329	338	346	355	364	372	381	389	398	406
506	415	424	432	441	449	458	467	475	484	492
507	501	509	518	526	535	544	552	561	569	578
508	586	595	603	612	621	629	638	646	655	663
509	672	680	689	697	706	714	723	731	740	749
510	757	766	774	783	791	800	808	817	825	834
511	842	851	859	868	876	885	893	902	910	919
512	927	935	944	952	961	969	978	986	995	*003
513	71 012	020	029	037	046	054	063	071	079	088
514	096	105	113	122	130	139	147	155	164	172
515	181	189	198	206	214	223	231	240	248	257
516	265	273	282	290	299	307	315	324	332	341
517	349	357	366	374	383	391	399	408	416	425
518	433	441	450	458	466	475	483	492	500	508
519	517	525	533	542	550	559	567	575	584	592
520	600	609	617	625	634	642	650	659	667	675
521	684	692	700	709	717	725	734	742	750	759
522	767	775	784	792	800	809	817	825	834	842
523	850	858	867	875	883	892	900	908	917	925
524	933	941	950	958	966	975	983	991	999	*008
525	72 016	024	032	041	049	057	066	074	082	090
526	099	107	115	123	132	140	148	156	165	173
527	181	189	198	206	214	222	230	239	247	255
528	263	272	280	288	296	304	313	321	329	337
529	346	354	362	370	378	387	395	403	411	419
530	428	436	444	452	460	469	477	485	493	501
531	509	518	526	534	542	550	558	567	575	583
532	591	599	607	616	624	632	640	648	656	665
533	673	681	689	697	705	713	722	730	738	746
534	754	762	770	779	787	795	803	811	819	827
535	835	843	852	860	868	876	884	892	900	908
536	916	925	933	941	949	957	965	973	981	989
537	997	*006	*014	*022	*030	*038	*046	*054	*062	*070
538	73 078	086	094	102	111	119	127	135	143	151
539	159	167	175	183	191	199	207	215	223	231
540	239	247	255	263	272	280	288	296	304	312
541	320	328	336	344	352	360	368	376	384	392
542	400	408	416	424	432	440	448	456	464	472
543	480	488	496	504	512	520	528	536	544	552
544	560	568	576	584	592	600	608	616	624	632
545	640	648	656	664	672	679	687	695	703	711
546	719	727	735	743	751	759	767	775	783	791
547	799	807	815	823	830	838	846	854	862	870
548	878	886	894	902	910	918	926	933	941	949
549	957	965	973	981	989	997	*005	*013	*020	*028
550	74 036	044	052	060	068	076	084	092	099	107
N.	0	1	2	3	4	5	6	7	8	9

Proportional parts

	9
1	0,9
2	1,8
3	2,7
4	3,6
5	4,5
6	5,4
7	6,3
8	7,2
9	8,1

	8
1	0,8
2	1,6
3	2,4
4	3,2
5	4,0
6	4,8
7	5,6
8	6,4
9	7,2

	7
1	0,7
2	1,4
3	2,1
4	2,8
5	3,5
6	4,2
7	4,9
8	5,6
9	6,3

Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts
550	74 036	044	052	060	068	076	084	092	099	107	
551	115	123	131	139	147	155	162	170	178	186	
552	194	202	210	218	225	233	241	249	257	265	
553	273	280	288	296	304	312	320	327	335	343	
554	351	359	367	374	382	390	398	406	414	421	
555	429	437	445	453	461	468	476	484	492	500	
556	507	515	523	531	539	547	554	562	570	578	
557	586	593	601	609	617	624	632	640	648	656	
558	663	671	679	687	695	702	710	718	726	733	
559	741	749	757	764	772	780	788	796	803	811	
560	819	827	834	842	850	858	865	873	881	889	**8**
561	896	904	912	920	927	935	943	950	958	966	1 | 0,8
562	974	981	989	997	*005	*012	*020	*028	*035	*043	2 | 1,6
563	75 051	059	066	074	082	089	097	105	113	120	3 | 2,4
564	128	136	143	151	159	166	174	182	189	197	4 | 3,2
565	205	213	220	228	236	243	251	259	266	274	5 | 4,0
566	282	289	297	305	312	320	328	335	343	351	6 | 4,8
567	358	366	374	381	389	397	404	412	420	427	7 | 5,6
568	435	442	450	458	465	473	481	488	496	504	8 | 6,4
569	511	519	526	534	542	549	557	565	572	580	9 | 7,2
570	587	595	603	610	618	626	633	641	648	656	
571	664	671	679	686	694	702	709	717	724	732	
572	740	747	755	762	770	778	785	793	800	808	
573	815	823	831	838	846	853	861	868	876	884	
574	891	899	906	914	921	929	937	944	952	959	
575	967	974	982	989	997	*005	*012	*020	*027	*035	
576	76 042	050	057	065	072	080	087	095	103	110	
577	118	125	133	140	148	155	163	170	178	185	
578	193	200	208	215	223	230	238	245	253	260	
579	268	275	283	290	298	305	313	320	328	335	
580	343	350	358	365	373	380	388	395	403	410	**7**
581	418	425	433	440	448	455	462	470	477	485	1 | 0,7
582	492	500	507	515	522	530	537	545	552	559	2 | 1,4
583	567	574	582	589	597	604	612	619	626	634	3 | 2,1
584	641	649	656	664	671	678	686	693	701	708	4 | 2,8
585	716	723	730	738	745	753	760	768	775	782	5 | 3,5
586	790	797	805	812	819	827	834	842	849	856	6 | 4,2
587	864	871	879	886	893	901	908	916	923	930	7 | 4,9
588	938	945	953	960	967	975	982	989	997	*004	8 | 5,6
589	77 012	019	026	034	041	048	056	063	070	078	9 | 6,3
590	085	093	100	107	115	122	129	137	144	151	
591	159	166	173	181	188	195	203	210	217	225	
592	232	240	247	254	262	269	276	283	291	298	
593	305	313	320	327	335	342	349	357	364	371	
594	379	386	393	401	408	415	422	430	437	444	
595	452	459	466	474	481	488	495	503	510	517	
596	525	532	539	546	554	561	568	576	583	590	
597	597	605	612	619	627	634	641	648	656	663	
598	670	677	685	692	699	706	714	721	728	735	
599	743	750	757	764	772	779	786	793	801	808	
600	815	822	830	837	844	851	859	866	873	880	
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9
600	77 815	822	830	837	844	851	859	866	873	880
601	887	895	902	909	916	924	931	938	945	952
602	960	967	974	981	988	996	*003	*010	*017	*025
603	78 032	039	046	053	061	068	075	082	089	097
604	104	111	118	125	132	140	147	154	161	168
605	176	183	190	197	204	211	219	226	233	240
606	247	254	262	269	276	283	290	297	305	312
607	319	326	333	340	347	355	362	369	376	383
608	390	398	405	412	419	426	433	440	447	455
609	462	469	476	483	490	497	504	512	519	526
610	533	540	547	554	561	569	576	583	590	597
611	604	611	618	625	633	640	647	654	661	668
612	675	682	689	696	704	711	718	725	732	739
613	746	753	760	767	774	781	789	796	803	810
614	817	824	831	838	845	852	859	866	873	880
615	888	895	902	909	916	923	930	937	944	951
616	958	965	972	979	986	993	*000	*007	*014	*021
617	79 029	036	043	050	057	064	071	078	085	092
618	099	106	113	120	127	134	141	148	155	162
619	169	176	183	190	197	204	211	218	225	232
620	239	246	253	260	267	274	281	288	295	302
621	309	316	323	330	337	344	351	358	365	372
622	379	386	393	400	407	414	421	428	435	442
623	449	456	463	470	477	484	491	498	505	511
624	518	525	532	539	546	553	560	567	574	581
625	588	595	602	609	616	623	630	637	644	650
626	657	664	671	678	685	692	699	706	713	720
627	727	734	741	748	754	761	768	775	782	789
628	796	803	810	817	824	831	837	844	851	858
629	865	872	879	886	893	900	906	913	920	927
630	934	941	948	955	962	969	975	982	989	996
631	80 003	010	017	024	030	037	044	051	058	065
632	072	079	085	092	099	106	113	120	127	134
633	140	147	154	161	168	175	182	188	195	202
634	209	216	223	229	236	243	250	257	264	271
635	277	284	291	298	305	312	318	325	332	339
636	346	353	359	366	373	380	387	393	400	407
637	414	421	428	434	441	448	455	462	468	475
638	482	489	496	502	509	516	523	530	536	543
639	550	557	564	570	577	584	591	598	604	611
640	618	625	632	638	645	652	659	665	672	679
641	686	693	699	706	713	720	726	733	740	747
642	754	760	767	774	781	787	794	801	808	814
643	821	828	835	841	848	855	862	868	875	882
644	889	895	902	909	916	922	929	936	943	949
645	956	963	969	976	983	990	996	*003	*010	*017
646	81 023	030	037	043	050	057	064	070	077	084
647	090	097	104	111	117	124	131	137	144	151
648	158	164	171	178	184	191	198	204	211	218
649	224	231	238	245	251	258	265	271	278	285
650	291	298	305	311	318	325	331	338	345	351
N.	0	1	2	3	4	5	6	7	8	9

Proportional parts

	8
1	0,8
2	1,6
3	2,4
4	3,2
5	4,0
6	4,8
7	5,6
8	6,4
9	7,2

	7
1	0,7
2	1,4
3	2,1
4	2,8
5	3,5
6	4,2
7	4,9
8	5,6
9	6,3

	6
1	0,6
2	1,2
3	1,8
4	2,4
5	3,0
6	3,6
7	4,2
8	4,8
9	5,4

Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts
650	81 291	298	305	311	318	325	331	338	345	351	
651	358	365	371	378	385	391	398	405	411	418	
652	425	431	438	445	451	458	465	471	478	485	
653	491	498	505	511	518	525	531	538	544	551	
654	558	564	571	578	584	491	598	604	611	617	
655	624	631	637	644	651	657	664	671	677	684	
656	690	697	704	710	717	723	730	737	743	750	
657	757	763	770	776	783	790	796	803	809	816	
658	823	829	836	842	849	856	862	869	875	882	
659	889	895	902	908	915	921	928	935	941	948	
660	954	961	968	974	981	987	994	*000	*007	*014	**7**
661	82 020	027	033	040	046	053	060	066	073	079	1 | 0,7
662	086	092	099	105	112	119	125	132	138	145	2 | 1,4
663	151	158	164	171	178	184	191	197	204	210	3 | 2,1
664	217	223	230	236	243	249	256	263	269	276	4 | 2,8
665	282	289	295	302	308	315	321	328	334	341	5 | 3,5
666	347	354	360	367	373	380	387	393	400	406	6 | 4,2
667	413	419	426	432	439	445	452	458	465	471	7 | 4,9
668	478	484	491	497	504	510	517	523	530	536	8 | 5,6
669	543	549	556	562	569	575	582	588	595	601	9 | 6,3
670	607	614	620	627	633	640	646	653	659	666	
671	672	679	685	692	698	705	711	718	724	730	
672	737	743	750	756	763	769	776	782	789	795	
673	802	808	814	821	827	835	840	847	853	860	
674	866	872	879	885	892	898	905	911	918	924	
675	930	937	943	950	956	963	969	975	982	988	
676	995	*001	*008	*014	*020	*027	*033	*040	*046	*052	
677	83 059	065	072	078	085	091	097	104	110	117	
678	123	129	136	142	149	155	161	168	174	181	
679	187	193	200	206	213	219	225	232	238	245	
680	251	257	264	270	276	283	289	296	302	308	**6**
681	315	321	327	334	340	347	353	359	366	372	1 | 0,6
682	378	385	391	398	404	410	417	423	429	436	2 | 1,2
683	442	448	455	461	467	474	480	487	493	499	3 | 1,8
684	506	512	518	525	531	537	544	550	556	563	4 | 2,4
685	569	575	582	588	594	601	607	613	620	626	5 | 3,0
686	632	639	645	651	658	664	670	677	683	689	6 | 3,6
687	696	702	708	715	721	727	734	740	746	753	7 | 4,2
688	759	765	771	778	784	790	797	803	809	816	8 | 4,8
689	822	828	835	841	847	853	860	866	872	879	9 | 5,4
690	885	891	897	904	910	916	923	929	935	942	
691	948	954	960	967	973	979	985	992	998	*004	
692	84 011	017	023	029	036	042	048	055	061	067	
693	073	080	086	092	098	105	111	117	123	130	
694	136	142	148	155	161	167	173	180	186	192	
695	198	205	211	217	223	230	236	242	248	255	
696	261	267	273	280	286	292	298	305	311	317	
697	323	330	336	342	348	354	361	367	373	379	
698	386	392	398	404	410	417	423	429	435	442	
699	448	454	460	466	473	479	485	491	497	504	
700	510	516	522	528	535	541	547	553	559	566	
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9
700	84 510	516	522	528	535	541	547	553	559	566
701	572	578	584	590	597	603	609	615	621	628
702	634	640	646	652	658	665	671	677	683	689
703	696	702	708	714	720	726	733	739	745	751
704	757	763	770	776	782	788	794	800	807	813
705	819	825	831	837	844	850	856	862	868	874
706	880	887	893	899	905	911	917	924	930	936
707	942	948	954	960	967	973	979	985	991	997
708	85 003	009	016	022	028	034	040	046	052	058
709	065	071	077	083	089	095	101	107	114	120
710	126	132	138	144	150	156	163	169	175	181
711	187	193	199	205	211	217	224	230	236	242
712	248	254	260	266	272	278	285	291	297	303
713	309	315	321	327	333	339	345	352	358	364
714	370	376	382	388	394	400	406	412	418	425
715	431	437	443	449	455	461	467	473	479	485
716	491	497	503	509	516	522	528	534	540	546
717	552	558	564	570	576	582	588	594	600	606
718	612	618	625	631	637	643	649	655	661	667
719	673	679	685	691	697	703	709	715	721	727
720	733	739	745	751	757	763	769	775	781	788
721	794	800	806	812	818	824	830	836	842	848
722	854	860	866	872	878	884	890	896	902	908
723	914	920	926	932	938	944	950	956	962	968
724	974	980	986	992	998	*004	*010	*016	*022	*028
725	86 034	040	046	052	058	064	070	076	082	088
726	094	100	106	112	118	124	130	136	141	147
727	153	159	165	171	177	183	189	195	201	207
728	213	219	225	231	237	243	249	255	261	267
729	273	279	285	291	297	303	308	314	320	326
730	332	338	344	350	356	362	368	374	380	386
731	392	398	404	410	415	421	427	433	439	445
732	451	457	463	469	475	481	487	493	499	504
733	510	516	522	528	534	540	546	552	558	564
734	570	576	581	587	593	599	605	611	617	623
735	629	635	641	646	652	658	664	670	676	682
736	688	694	700	705	711	717	723	729	735	741
737	747	753	759	764	770	776	782	788	794	800
738	806	812	817	823	829	835	841	847	853	859
739	864	870	876	882	888	894	900	906	911	917
740	923	929	935	941	947	953	958	964	970	976
741	982	988	994	999	*005	*011	*017	*023	*029	*035
742	87 040	046	052	058	064	070	075	081	087	093
743	099	105	111	116	122	128	134	140	146	151
744	157	163	169	175	181	186	192	198	204	210
745	216	221	227	233	239	245	251	256	262	268
746	274	280	286	291	297	303	309	315	320	326
747	332	338	344	349	355	361	367	373	379	384
748	390	396	402	408	413	419	425	431	437	442
749	448	454	460	466	471	477	483	489	495	500
750	506	512	518	523	529	535	541	547	552	558
N.	0	1	2	3	4	5	6	7	8	9

Proportional parts

	7
1	0,7
2	1,4
3	2,1
4	2,8
5	3,5
6	4,2
7	4,9
8	5,6
9	6,3

	6
1	0,6
2	1,2
3	1,8
4	2,4
5	3,0
6	3,6
7	4,2
8	4,8
9	5,4

	5
1	0,5
2	1,0
3	1,5
4	2,0
5	2,5
6	3,0
7	3,5
8	4,0
9	4,5

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts
750	87 506	512	518	523	529	535	541	547	552	558	
751	564	570	576	581	587	593	599	604	610	616	
752	622	628	633	639	645	651	656	662	668	674	
753	679	685	691	697	703	708	714	720	726	731	
754	737	743	749	754	760	766	772	777	783	789	
755	795	800	806	812	818	823	829	835	841	846	
756	852	858	864	869	875	881	887	892	898	904	
757	910	915	921	927	933	938	944	950	955	961	
758	967	973	978	984	990	996	*001	*007	*013	*018	
759	88 024	030	036	041	047	053	058	064	070	076	
760	081	087	093	098	104	110	116	121	127	133	**6**
761	138	144	150	156	161	167	173	178	184	190	1 | 0,6
762	195	201	207	213	218	224	230	235	241	247	2 | 1,2
763	252	258	264	270	275	281	287	292	298	304	3 | 1,8
764	309	316	321	326	332	338	343	349	355	360	4 | 2,4
765	366	372	377	383	389	395	400	406	412	417	5 | 3,0
766	423	429	434	440	446	451	457	463	468	474	6 | 3,6
767	480	485	491	497	502	508	513	519	525	530	7 | 4,2
768	536	542	547	553	559	564	570	576	581	587	8 | 4,8
769	593	598	604	610	615	621	627	632	638	643	9 | 5,4
770	649	655	660	666	672	677	683	689	694	700	
771	705	711	717	722	728	734	739	745	750	756	
772	762	767	773	779	784	790	795	801	807	812	
773	818	824	829	835	840	846	852	857	863	868	
774	874	880	885	891	897	902	908	913	919	925	
775	930	936	941	947	953	958	964	969	975	981	
776	986	992	997	*003	*009	*014	*020	*025	*031	*037	
777	89 042	048	053	059	064	070	076	081	087	092	
778	098	104	109	115	120	126	131	137	143	148	
779	154	159	165	170	176	182	187	193	198	204	
780	209	215	221	226	232	237	243	248	254	260	**5**
781	265	271	276	282	287	293	298	304	310	315	1 | 0,5
782	321	326	332	337	343	348	354	360	365	371	2 | 1,0
783	376	382	387	393	398	404	409	415	421	426	3 | 1,5
784	432	437	443	448	454	459	465	470	476	481	4 | 2,0
785	487	492	498	504	509	515	520	526	531	537	5 | 2,5
786	542	548	553	559	564	570	575	581	586	592	6 | 3,0
787	597	603	609	614	620	625	631	636	642	647	7 | 3,5
788	653	658	664	669	675	680	686	691	697	702	8 | 4,0
789	708	713	719	724	730	735	741	746	752	757	9 | 4,5
790	763	768	774	779	785	790	796	801	807	812	
791	818	823	829	834	840	845	851	856	862	867	
792	873	878	883	889	894	900	905	911	916	922	
793	927	933	938	944	949	955	960	966	971	977	
794	982	988	993	998	*004	*009	*015	*020	*026	*031	
795	90 037	042	048	053	059	064	069	075	080	086	
796	091	097	102	108	113	119	124	129	135	140	
797	146	151	157	162	168	173	179	184	189	195	
798	200	206	211	217	222	227	233	238	244	249	
799	255	260	266	271	276	282	287	293	298	304	
800	309	314	320	325	331	336	342	347	352	358	
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts
800	90 309	314	320	325	331	336	342	347	352	358	
801	363	369	374	380	385	390	396	401	407	412	
802	417	423	428	434	439	445	450	455	461	466	
803	472	477	482	488	493	499	504	509	515	520	
804	526	531	536	542	547	553	558	563	569	574	
805	580	585	590	596	601	607	612	617	623	628	
806	634	639	644	650	655	660	666	671	677	682	
807	687	693	698	703	709	714	720	725	730	736	
808	741	747	752	757	763	768	773	779	784	789	
809	795	800	806	811	816	822	827	832	838	843	
810	849	854	859	865	870	875	881	886	891	897	**6**
811	902	907	913	918	924	929	934	940	945	950	1 0,6
812	956	961	966	972	977	982	988	993	998	*004	2 1,2
813	91 009	014	020	025	030	036	041	046	052	057	3 1,8
814	062	068	073	078	084	089	094	100	105	110	4 2,4
815	116	121	126	132	137	142	148	153	158	164	5 3,0
816	169	174	180	185	190	196	201	206	212	217	6 3,6
817	222	228	233	238	243	249	254	259	265	270	7 4,2
818	275	281	286	291	297	302	307	312	318	323	8 4,8
819	328	334	339	344	350	355	360	365	371	376	9 5,4
820	381	387	392	397	403	408	413	418	424	429	
821	434	440	445	450	455	461	466	471	477	482	
822	487	492	498	503	508	514	519	524	529	535	
823	540	545	551	556	561	566	572	577	582	587	
824	593	598	603	609	614	619	624	630	635	640	
825	645	651	656	661	666	672	677	682	687	693	
826	698	703	709	714	719	724	730	735	740	745	
827	751	756	761	766	772	777	782	787	793	798	
828	803	808	814	819	824	829	834	840	845	850	
829	855	861	866	871	876	882	887	892	897	903	
830	908	913	918	924	929	934	939	944	950	955	**5**
831	960	965	971	976	981	986	991	997	*002	*007	1 0,5
832	92 012	018	023	028	033	038	044	049	054	059	2 1,0
833	065	070	075	080	085	091	096	101	106	111	3 1,5
834	117	122	127	132	137	143	148	153	158	163	4 2,0
835	169	174	179	184	189	195	200	205	210	215	5 2,5
836	221	226	231	236	241	247	252	257	262	267	6 3,0
837	273	278	283	288	293	298	304	309	314	319	7 3,5
838	324	330	335	340	345	350	355	361	366	371	8 4,0
839	376	381	387	392	397	402	407	412	418	423	9 4,5
840	428	433	438	443	449	454	459	464	469	474	
841	480	485	490	495	500	505	511	516	521	526	
842	531	536	542	547	552	557	562	567	572	578	
843	583	588	593	598	603	609	614	619	624	629	
844	634	639	645	650	655	660	665	670	675	681	
845	686	691	696	701	706	711	716	722	727	732	
846	737	742	747	752	758	763	768	773	778	783	
847	788	793	799	804	809	814	819	824	829	834	
848	840	845	850	855	860	865	870	875	881	886	
849	891	896	901	906	911	916	921	927	932	937	
850	942	947	952	957	962	967	973	978	983	988	
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts
850	92 942	947	952	957	962	967	973	978	983	988	
851	993	998	*003	*008	*013	*018	*024	*029	*034	*039	
852	93 044	049	054	059	064	069	075	080	085	090	
853	095	100	105	110	115	120	125	131	136	141	
854	146	151	156	161	166	171	176	181	186	192	
855	197	202	207	212	217	222	227	232	237	242	
856	247	252	258	263	268	273	278	283	288	293	**6**
857	298	303	308	313	318	323	328	334	339	344	1 0,6
858	349	354	359	364	369	374	379	384	389	394	2 1,2
859	399	404	409	414	420	425	430	435	440	445	3 1,8
											4 2,4
860	450	455	460	465	470	475	480	485	490	495	5 3,0
861	500	505	510	515	520	526	531	536	541	546	6 3,6
862	551	556	561	566	571	576	581	586	591	596	7 4,2
863	601	606	611	616	621	626	631	636	641	646	8 4,8
864	651	656	661	666	671	676	682	687	692	697	9 5,4
865	702	707	712	717	722	727	732	737	742	747	
866	752	757	762	767	772	777	782	787	792	797	
867	802	807	812	817	822	827	832	837	842	847	
868	852	857	862	867	872	877	882	887	892	897	
869	902	907	912	917	922	927	932	937	942	947	
870	952	957	962	967	972	977	982	987	992	997	**5**
871	94 002	007	012	017	022	027	032	037	042	047	1 0,5
872	052	057	062	067	072	077	082	086	091	096	2 1,0
873	101	106	111	116	121	126	131	136	141	146	3 1,5
874	151	156	161	166	171	176	181	186	191	196	4 2,0
875	201	206	211	216	221	226	231	236	240	245	5 2,5
876	250	255	260	265	270	275	280	285	290	295	6 3,0
877	300	305	310	315	320	325	330	335	340	345	7 3,5
878	349	354	359	364	369	374	379	384	389	394	8 4,0
879	399	404	409	414	419	424	429	433	438	443	9 4,5
880	448	453	458	463	468	473	478	483	488	493	
881	498	503	507	512	517	522	527	532	537	542	
882	547	552	557	562	567	571	576	581	586	591	
883	596	601	606	611	616	621	626	630	635	640	
884	645	650	655	660	665	670	675	680	685	689	**4**
885	694	699	704	709	714	719	724	729	734	738	1 0,4
886	743	748	753	758	763	768	773	778	783	787	2 0,8
887	792	797	802	807	812	817	822	827	832	836	3 1,2
888	841	846	851	856	861	866	871	876	880	885	4 1,6
889	890	895	900	905	910	915	919	924	929	934	5 2,0
											6 2,4
890	939	944	949	954	959	963	968	973	978	983	7 2,8
891	988	993	998	*002	*007	*012	*017	*022	*027	*032	8 3,2
892	95 036	041	046	051	056	061	066	071	075	080	9 3,6
893	085	090	095	100	105	109	114	119	124	129	
894	134	139	143	148	153	158	163	168	173	177	
895	182	187	192	197	202	207	211	216	221	226	
896	231	236	240	245	250	255	260	265	270	274	
897	279	284	289	294	299	303	308	313	318	323	
898	328	332	337	342	347	352	357	361	366	371	
899	376	381	386	390	395	400	405	410	415	419	
900	424	429	434	439	444	448	453	458	463	468	
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts
900	95 424	429	434	439	444	448	453	458	463	468	
901	472	477	482	487	492	497	501	506	511	516	
902	521	525	530	535	540	545	550	554	559	564	
903	569	574	578	583	588	593	598	602	607	612	
904	617	622	626	631	636	641	646	650	655	660	
905	665	670	674	679	684	689	694	698	703	708	
906	713	718	722	727	732	737	742	746	751	756	
907	761	766	770	775	780	785	789	794	799	804	
908	809	813	818	823	828	832	837	842	847	852	
909	856	861	866	871	875	880	885	890	895	899	
910	904	909	914	918	923	928	933	938	942	947	**5**
911	952	957	961	966	971	976	980	985	990	995	1 | 0,5
912	999	*004	*009	*014	*019	*023	*028	*033	*038	*042	2 | 1,0
913	96 047	052	057	061	066	071	076	080	085	090	3 | 1,5
914	095	099	104	109	114	118	123	128	133	137	4 | 2,0
915	142	147	152	156	161	166	171	175	180	185	5 | 2,5
916	190	194	199	204	209	213	218	223	227	232	6 | 3,0
917	237	242	246	251	256	261	265	270	275	280	7 | 3,5
918	284	289	294	298	303	308	313	317	322	327	8 | 4,0
919	332	336	341	346	350	355	360	365	369	374	9 | 4,5
920	379	384	388	393	398	402	407	412	417	421	
921	426	431	435	440	445	450	454	459	464	468	
922	473	478	483	487	492	497	501	506	511	515	
923	520	525	530	534	539	544	548	553	558	562	
924	567	572	577	581	586	591	595	600	605	609	
925	614	619	624	628	633	638	642	647	652	656	
926	661	666	670	675	680	685	689	694	699	703	
927	708	713	717	722	727	731	736	741	745	750	
928	755	759	764	769	774	778	783	788	792	797	
929	802	806	811	816	820	825	830	834	839	844	
930	848	853	858	862	867	872	876	881	886	890	**4**
931	895	900	904	909	914	918	923	928	932	937	1 | 0,4
932	942	946	951	956	960	965	970	974	979	984	2 | 0,8
933	988	993	997	*002	*007	*011	*016	*021	*025	*030	3 | 1,2
934	97 035	039	044	049	053	058	063	067	072	077	4 | 1,6
935	081	086	090	095	100	104	109	114	118	123	5 | 2,0
936	128	132	137	142	146	151	155	160	165	169	6 | 2,4
937	174	179	183	188	192	197	202	206	211	216	7 | 2,8
938	220	225	230	234	239	243	248	253	257	262	8 | 3,2
939	267	271	276	280	285	290	294	299	304	308	9 | 3,6
940	313	317	322	327	331	336	340	345	350	354	
941	359	364	368	373	377	382	387	391	396	400	
942	405	410	414	419	424	428	433	437	442	447	
943	451	456	460	465	470	474	479	483	488	493	
944	497	502	506	511	516	520	525	529	534	539	
945	543	548	552	557	562	566	571	575	580	585	
946	589	594	598	603	607	612	617	621	626	630	
947	635	640	644	649	653	658	663	667	672	676	
948	681	685	690	695	699	704	708	713	717	722	
949	727	731	736	740	745	749	754	759	763	768	
950	772	777	782	786	791	795	800	804	809	813	
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts

FIVE-PLACE LOGARITHMS (Continued)

N.	0	1	2	3	4	5	6	7	8	9	Proportional parts
950	97 772	777	782	786	791	795	800	804	809	813	
951	818	823	827	832	836	841	845	850	855	859	
952	864	868	873	877	882	886	891	896	900	905	
953	909	914	918	923	928	932	937	941	946	950	
954	955	959	964	968	973	978	982	987	991	996	
955	98 000	005	009	014	019	023	028	032	037	041	
956	046	050	055	059	064	068	073	078	082	087	
957	091	096	100	105	109	114	118	123	127	132	
958	137	141	146	150	155	159	164	168	173	177	
959	182	186	191	195	200	204	209	214	218	223	
960	227	232	236	241	245	250	254	259	263	268	**5**
961	272	277	281	286	290	295	299	304	308	313	1 | 0,5
962	318	322	327	331	336	340	345	349	354	358	2 | 1,0
963	363	367	372	376	381	385	390	394	399	403	3 | 1,5
964	408	412	417	421	426	430	435	439	444	448	4 | 2,0
965	453	457	462	466	471	475	480	484	489	493	5 | 2,5
966	498	502	507	511	516	520	525	529	534	538	6 | 3,0
967	543	547	552	556	561	565	570	574	579	583	7 | 3,5
968	588	592	597	601	605	610	614	619	623	628	8 | 4,0
969	632	637	641	646	650	655	659	664	668	673	9 | 4,5
970	677	682	686	691	695	700	704	709	713	717	
971	722	726	731	735	740	744	749	753	758	762	
972	767	771	776	780	784	789	793	798	802	807	
973	811	816	820	825	829	834	838	843	847	851	
974	856	860	865	869	874	878	883	887	892	896	
975	900	905	909	914	918	923	927	932	936	941	
976	945	949	954	958	963	967	972	976	981	985	
977	989	994	998	*003	*007	*012	*016	*021	*025	*029	
978	99 034	038	043	047	052	056	061	065	069	074	
979	078	083	087	092	096	100	105	109	114	118	
980	123	127	131	136	140	145	149	154	158	162	**4**
981	167	171	176	180	185	189	193	198	202	207	1 | 0,4
982	211	216	220	224	229	233	238	242	247	251	2 | 0,8
983	255	260	264	269	273	277	282	286	291	295	3 | 1,2
984	300	304	308	313	317	322	326	330	335	339	4 | 1,6
985	344	348	352	357	361	366	370	374	379	383	5 | 2,0
986	388	392	396	401	405	410	414	419	423	427	6 | 2,4
987	432	436	441	445	449	454	458	463	467	471	7 | 2,8
988	476	480	484	489	493	498	502	506	511	515	8 | 3,2
989	520	524	528	533	537	542	546	550	555	559	9 | 3,6
990	564	568	572	577	581	585	590	594	599	603	
991	607	612	616	621	625	629	634	638	642	647	
992	651	656	660	664	669	673	677	682	686	691	
993	695	699	704	708	712	717	721	726	730	734	
994	739	743	747	752	756	760	765	769	774	778	
995	782	787	791	795	800	804	808	813	817	822	
996	826	830	835	839	843	848	852	856	861	865	
997	870	874	878	883	887	891	896	900	904	909	
998	913	917	922	926	930	935	939	944	948	952	
999	957	961	965	970	974	978	983	987	991	996	
1000	00 000	004	009	013	017	022	026	030	035	039	
N.	0	1	2	3	4	5	6	7	8	9	Proportional parts

NATURAL LOGARITHMS

NATURAL OR NAPERIAN LOGARITHMS OF THE NUMBERS FROM 1 TO 1109

To find the logarithm of a number which is $\frac{1}{10}$ or 10 times etc. a number whose logarithm is given, subtract from or add to the given logarithm the logarithm of 10.

Thus log 1.6 = log 16 − log 10
log 160 = log 16 + log 10 etc.

N	Log	N	Log	N	Log	N	Log	N	Log
0	—	**20**	2. 99 573	**40**	3. 68 888	**60**	4. 09 434	**80**	4. 38 203
1	0. 00 000	21	3. 04 452	41	3. 71 357	61	4. 11 087	81	4. 39 445
2	0. 69 315	22	3. 09 104	42	3. 73 767	62	4. 12 713	82	4. 40 672
3	1. 09 861	23	3. 13 459	43	3. 76 120	63	4. 14 313	83	4. 41 884
4	1. 38 629	24	3. 17 805	44	3. 78 419	64	4. 15 888	84	4. 43 082
5	1. 60 944	25	3. 21 888	45	3. 80 666	65	4. 17 439	85	4. 44 265
6	1. 79 176	26	3. 25 810	46	3. 82 864	66	4. 18 965	86	4. 45 435
7	1. 94 591	27	3. 29 584	47	3. 85 015	67	4. 20 469	87	4. 46 591
8	2. 07 944	28	3. 33 220	48	3. 87 120	68	4. 21 951	88	4. 47 734
9	2. 19 722	29	3. 36 730	49	3. 89 182	69	4. 23 411	89	4. 48 864
10	2. 30 259	**30**	3. 40 120	**50**	3. 91 202	**70**	4. 24 850	**90**	4. 49 981
11	2. 39 790	31	3. 43 399	51	3. 93 183	71	4. 26 268	91	4. 51 086
12	2. 48 491	32	3. 46 574	52	3. 95 124	72	4. 27 667	92	4. 52 179
13	2. 56 495	33	3. 49 651	53	3. 97 029	73	4. 29 046	93	4. 53 260
14	2. 63 906	34	3. 52 636	54	3. 98 898	74	4. 30 407	94	4. 54 329
15	2. 70 805	35	3. 55 535	55	4. 00 733	75	4. 31 749	95	4. 55 388
16	2. 77 259	36	3. 58 352	56	4. 02 535	76	4. 33 073	96	4. 56 435
17	2. 83 321	37	3. 61 092	57	4. 04 305	77	4. 34 381	97	4. 57 471
18	2. 89 037	38	3. 63 759	58	4. 06 044	78	4. 35 671	98	4. 58 497
19	2. 94 444	39	3. 66 356	59	4. 07 754	79	4. 36 945	99	4. 59 512
20	2. 99 573	**40**	3. 68 888	**60**	4. 09 434	**80**	4. 38 203	**100**	4. 60 517

NATURAL LOGARITHMS (Continued)

N	Log	0	1	2	3	4	5	6	7	8	9
10	4. 6	0517	1512	2497	3473	4439	5396	6344	7283	8213	9135
11	4. 7	0048	0953	1850	2739	3620	4493	5359	6217	7068	7912
12		8749	9579	*0402	*1218	*2028	*2831	*3628	*4419	*5203	*5981
13	4. 8	6753	7520	8280	9035	9784	*0527	*1265	*1998	*2725	*3447
14	4. 9	4164	4876	5583	6284	6981	7673	8361	9043	9721	*0395
15	5. 0	1064	1728	2388	3044	3695	4343	4986	5625	6260	6890
16		7517	8140	8760	9375	9987	*0595	*1199	*1799	*2396	*2990
17	5. 1	3580	4166	4749	5329	5906	6479	7048	7615	8178	8739
18		9296	9850	*0401	*0949	*1494	*2036	*2575	*3111	*3644	*4175
19	5. 2	4702	5227	5750	6269	6786	7300	7811	8320	8827	9330
20		9832	*0330	*0827	*1321	*1812	*2301	*2788	*3272	*3754	*4233
21	5. 3	4711	5186	5659	6129	6598	7064	7528	7990	8450	8907
22		9363	9816	*0268	*0717	*1165	*1610	*2053	*2495	*2935	*3372
23	5. 4	3808	4242	4674	5104	5532	5959	6383	6806	7227	7646
24		8064	8480	8894	9306	9717	*0126	*0533	*0939	*1343	*1745
25	5. 5	2146	2545	2943	3339	3733	4126	4518	4908	5296	5683
26		6068	6452	6834	7215	7595	7973	8350	8725	9099	9471
27		9842	*0212	*0580	*0947	*1313	*1677	*2040	*2402	*2762	*3121
28	5. 6	3479	3835	4191	4545	4897	5249	5599	5948	6296	6643
29		6988	7332	7675	8017	8358	8698	9036	9373	9709	*0044
30	5. 7	0378	0711	1043	1373	1703	2031	2359	2685	3010	3334
31		3657	3979	4300	4620	4939	5257	5574	5890	6205	6519
32		6832	7144	7455	7765	8074	8383	8690	8996	9301	9606
33		9909	*0212	*0513	*0814	*1114	*1413	*1711	*2008	*2305	*2600
34	5. 8	2895	3188	3481	3773	4064	4354	4644	4932	5220	5507
35		5793	6079	6363	6647	6930	7212	7493	7774	8053	8332
36		8610	8888	9164	9440	9715	9990	*0263	*0536	*0808	*1080
37	5. 9	1350	1620	1889	2158	2426	2693	2959	3225	3489	3754
38		4017	4280	4542	4803	5064	5324	5584	5842	6101	6358
39		6615	6871	7126	7381	7635	7889	8141	8394	8645	8899
40		9146	9396	9645	9894	*0141	*0389	*0635	*0881	*1127	*1372
41	6. 0	1616	1859	2102	2345	2587	2828	3069	3309	3548	3787
42		4025	4263	4501	4737	4973	5209	5444	5678	5912	6146
43		6379	6611	6843	7074	7304	7535	7764	7993	8222	8450
44		8677	8904	9131	9357	9582	9807	*0032	*0256	*0479	*0702
45	6. 1	0925	1147	1368	1589	1810	2030	2249	2468	2687	2905
46		3123	3340	3556	3773	3988	4204	4419	4633	4847	5060
47		5273	5486	5698	5910	6121	6331	6542	6752	6961	7170
48		7379	7587	7794	8002	8208	8415	8621	8826	9032	9236
49		9441	9644	9848	*0051	*0254	*0456	*0658	*0859	*1060	*1261
50	6. 2	1461	1661	1860	2059	2258	2456	2654	2851	3048	3245
51		3441	3637	3832	4028	4222	4417	4611	4804	4998	5190
52		5383	5575	5767	5958	6149	6340	6530	6720	6910	7099
53		7288	7476	7664	7852	8040	8227	8413	8600	8786	8972
54		9157	9342	9527	9711	9895	*0079	*0262	*0445	*0628	*0810
55	6. 3	0992	1173	1355	1536	1716	1897	2077	2257	2436	2615
56		2794	2972	3150	3328	3505	3683	3859	4036	4212	4388
57		4564	4739	4914	5089	5263	5437	5611	5784	5957	6130
58		6303	6475	6647	6819	6990	7161	7332	7502	7673	7843
59		8012	8182	8351	8519	8688	8856	9024	9192	9359	9526
60		9693	9859	*0026	*0192	*0357	*0523	*0688	*0853	*1017	*1182
N	Log	0	1	2	3	4	5	6	7	8	9

NATURAL LOGARITHMS (Continued)

N	Log	0	1	2	3	4	5	6	7	8	9
60	6. 3	9693	9859	*0026	*0192	*0357	*0523	*0688	*0853	*1017	*1182
61	6. 4	1346	1510	1673	1836	1999	2162	2325	2487	2649	2811
62		2972	3133	3294	3455	3615	3775	3935	4095	4254	4413
63		4572	4731	4889	5047	5205	5362	5520	5677	5834	5990
64		6147	6303	6459	6614	6770	6925	7080	7235	7389	7543
65		7697	7851	8004	8158	8311	8464	8616	8768	8920	9072
66		9224	9375	9527	9677	9828	9979	*0129	*0279	*0429	*0578
67	6. 5	0728	0877	1026	1175	1323	1471	1619	1767	1915	2062
68		2209	2356	2503	2649	2796	2942	3088	3233	3379	3524
69		3669	3814	3959	4103	4247	4391	4535	4679	4822	4965
70		5108	5251	5393	5536	5678	5820	5962	6103	6244	6386
71		6526	6667	6808	6948	7088	7228	7368	7508	7647	7786
72		7925	8064	8203	8341	8479	8617	8755	8893	9030	9167
73		9304	9441	9578	9715	9851	9987	*0123	*0259	*0394	*0530
74	6. 6	0665	0800	0935	1070	1204	1338	1473	1607	1740	1874
75		2007	2141	2274	2407	2539	2672	2804	2936	3068	3200
76		3332	3463	3595	3726	3857	3988	4118	4249	4379	4509
77		4639	4769	4898	5028	5157	5286	5415	5544	5673	5801
78		5929	6058	6185	6313	6441	6568	6696	6823	6950	7077
79		7203	7330	7456	7582	7870	7834	7960	8085	8211	8336
80		8461	8586	8711	8835	8960	9084	9208	9332	9456	9580
81		9703	9827	9950	*0073	*0196	*0319	*0441	*0564	*0686	*0808
82	6. 7	0930	1052	1174	1296	1417	1538	1659	1780	1901	2022
83		2143	2263	2383	2503	2623	2743	2863	2982	3102	3221
84		3340	3459	3578	3697	3815	3934	4052	4170	4288	4406
85		4524	4641	4759	4876	4993	5110	5227	5344	5460	5577
86		5693	5809	5926	6041	6157	6273	6388	6504	6619	6734
87		6849	6964	7079	7194	7308	7422	7537	7651	7765	7878
88		7992	8106	8219	8333	8446	8559	8672	8784	8897	9010
89		9122	9234	9347	9459	9571	9682	9794	9906	*0017	*0128
90	6. 8	0239	0351	0461	0572	0683	0793	0904	1014	1124	1235
91		1344	1454	1564	1674	1783	1892	2002	2111	2220	2329
92		2437	2546	2655	2763	2871	2979	3087	3195	3303	3411
93		3518	3626	3733	3841	3948	4055	4162	4268	4375	4482
94		4588	4694	4801	4907	5013	5118	5224	5330	5435	5541
95		5646	5751	5857	5961	6066	6171	6276	6380	6485	6589
96		6693	6797	6901	7005	7109	7213	7316	7420	7523	7626
97		7730	7833	7936	8038	8141	8244	8346	8449	8551	8653
98		8755	8857	8959	9061	9163	9264	9366	9467	9568	9669
99		9770	9871	9972	*0073	*0174	*0274	*0375	*0475	*0575	*0675
100	6. 9	0776	0875	0975	1075	1175	1274	1374	1473	1572	1672
101		1771	1870	1968	2067	2166	2264	2363	2461	2560	2658
102		2756	2854	2952	3049	3147	3245	3342	3440	3537	3634
103		3731	3828	3925	4022	4119	4216	4312	4409	4505	4601
104		4698	4794	4890	4986	5081	5177	5273	5368	5464	5559
105		5655	5750	5845	5940	6035	6130	6224	6319	6414	6508
106		6602	6697	6791	6885	6979	7073	7167	7261	7354	7448
107		7541	7635	7728	7821	7915	8008	8101	8193	8286	8379
108		8472	8564	8657	8749	8841	8934	9026	9118	9210	9302
109		9393	9485	9577	9668	9760	9851	9942	*0033	*0125	*0216
110	7. 0	0307	0397	0488	0579	0670	0760	0851	0941	1031	1121
N	Log	0	1	2	3	4	5	6	7	8	9

NATURAL SINES, COSINES, TANGENTS AND COTANGENTS

Degrees.	Sin.	Cos.	Tan.	Cot.	Degrees.
0° 00′	0.0000	1.0000	0.0000	∞	90° 00′
10	.0029	1.0000	.0029	343.77	50
20	.0058	1.0000	.0058	171.89	40
30	.0087	1.0000	.0087	114.59	30
40	.0116	.9999	.0116	85.940	20
50	.0145	.9999	.0145	68.750	10
1° 00′	0.0175	0.9998	0.0175	57.290	89° 00′
10	.0204	.9998	.0204	49.104	50
20	.0233	.9997	.0233	42.964	40
30	.0262	.9997	.0262	38.188	30
40	.0291	.9996	.0291	34.368	20
50	.0320	.9995	.0320	31.242	10
2° 00′	0.0349	0.9994	0.0349	28.636	88° 00′
10	.0378	.9993	.0378	26.432	50
20	.0407	.9992	.0407	24.542	40
30	.0436	.9990	.0437	22.904	30
40	.0465	.9989	.0466	21.470	20
50	.0494	.9988	.0495	20.206	10
3° 00′	0.0523	0.9986	0.0524	19.081	87° 00′
10	.0552	.9985	.0553	18.075	50
20	.0581	.9983	.0582	17.169	40
30	.0610	.9981	.0612	16.350	30
40	.0640	.9980	.0641	15.605	20
50	.0669	.9978	.0670	14.924	10
4° 00′	0.0698	0.9976	0.0699	14.301	86° 00′
10	.0727	.9974	.0729	13.727	50
20	.0756	.9971	.0758	13.197	40
30	.0785	.9969	.0787	12.706	30
40	.0814	.9967	.0816	12.251	20
50	.0843	.9964	.0846	11.826	10
5° 00′	0.0872	0.9962	0.0875	11.430	85° 00′
10	.0901	.9959	.0904	11.059	50
20	.0929	.9957	.0934	10.712	40
30	.0958	.9954	.0963	10.385	30
40	.0987	.9951	.0992	10.078	20
50	.1016	.9948	.1022	9.7882	10
6° 00′	0.1045	0.9945	0.1051	9.5144	84° 00′
10	.1074	.9942	.1080	9.2553	50
20	.1103	.9939	.1110	9.0098	40
30	.1132	.9936	.1139	8.7769	30
40	.1161	.9932	.1169	8.5555	20
50	.1190	.9929	.1198	8.3450	10
7° 00′	0.1219	0.9925	0.1228	8.1443	83° 00′
10	.1248	.9922	.1257	7.9530	50
20	.1276	.9918	.1287	7.7704	40
30	.1305	.9914	.1317	7.5958	30
40	.1334	.9911	.1346	7.4287	20
50	.1363	.9907	.1376	7.2687	10
8° 00′	0.1392	0.9903	0.1405	7.1154	82° 00′
10	.1421	.9899	.1435	6.9682	50
20	.1449	.9894	.1465	6.8269	40
30	.1478	.9890	.1495	6.6912	30
40	.1507	.9886	.1524	6.5606	20
50	.1536	.9881	.1554	6.4348	10
9° 00′	0.1564	0.9877	0.1584	6.3138	81° 00′
Degrees.	Cos.	Sin.	Cot.	Tan.	Degrees.

NATURAL SINES, COSINES, TANGENTS AND COTANGENTS (Continued)

Degrees.	Sin.	Cos.	Tan.	Cot.	Degrees.
9° 00′	0.1564	0.9877	0.1584	6.3138	81° 00′
10	.1593	.9872	.1614	6.1970	50
20	.1622	.9868	.1644	6.0844	40
30	.1650	.9863	.1673	5.9758	30
40	.1679	.9858	.1703	5.8708	20
50	.1708	.9853	.1733	5.7694	10
10° 00′	0.1736	0.9848	0.1763	5.6713	80° 00
10	.1765	.9843	.1793	5.5764	50
20	.1794	.9838	.1823	5.4845	40
30	.1822	.9833	.1853	5.3955	30
40	.1851	.9827	.1883	5.3093	20
50	.1880	.9822	.1914	5.2257	10
11° 00′	0.1908	0.9816	0.1944	5.1446	79° 00′
10	.1937	.9811	.1974	5.0658	50
20	.1965	.9805	.2004	4.9894	40
30	.1994	.9799	.2035	4.9152	30
40	.2022	.9793	.2065	4.8430	20
50	.2051	.9787	.2095	.7729	10
12° 00′	0.2079	0.9781	0.2126	4.7046	78° 00
10	.2108	.9775	.2156	4.6382	50
20	.2136	.9769	.2186	4.5736	40
30	.2164	.9763	.2217	4.5107	30
40	.2193	.9757	.2247	4.4494	20
50	.2221	.9750	.2278	4.3897	10
13° 00′	0.2250	0.9744	0.2309	4.3315	77° 00′
10	.2278	.9737	.2339	4.2747	50
20	.2306	.9730	.2370	4.2193	40
30	.2334	.9724	.2401	4.1653	30
40	.2363	.9717	.2432	4.1126	20
50	.2391	.9710	.2462	4.0611	10
14° 00′	0.2419	0.9703	0.2493	4.0108	76° 00′
10	.2447	.9696	.2524	3.9617	50
20	.2476	.9689	.2555	3.9136	40
30	.2504	.9681	.2586	3.8667	30
40	.2532	.9674	.2617	3.8208	20
50	.2560	.9667	.2648	3.7760	10
15° 00′	0.2588	0.9659	0.2679	3.7321	75° 00′
10	.2616	.9652	.2711	3.6891	50
20	.2644	.9644	.2742	3.6470	40
30	.2672	.9636	.2773	3.6059	30
40	.2700	.9628	.2805	3.5656	20
50	.2728	.9621	.2836	3.5261	10
16° 00′	0.2756	0.9613	0.2867	3.4874	74° 00′
10	.2784	.9605	.2899	3.4495	50
20	.2812	.9596	.2931	3.4124	40
30	.2840	.9588	.2962	3.3759	30
40	.2868	.9580	.2994	3.3402	20
50	.2896	.9572	.3026	3.3052	10
17° 00′	0.2924	0.9563	0.3057	3.2709	73° 00′
10	.2952	.9555	.3089	3.2371	50
20	.2979	.9546	.3121	3.2041	40
30	.3007	.9537	.3153	3.1716	30
40	.3035	.9528	.3185	3.1397	20
50	.3062	.9520	.3217	3.1084	10
18° 00′	0.3090	0.9511	0.3249	3.0777	72° 00′
Degrees.	Cos.	Sin.	Cot.	Tan.	Degrees.

NATURAL SINES, COSINES, TANGENTS AND COTANGENTS (Continued)

Degrees.	Sin.	Cos.	Tan.	Cot.	Degrees.
18° 00′	0.3090	0.9511	0.3249	3.0777	72° 00′
10	.3118	.9502	.3281	3.0475	50
20	.3145	.9492	.3314	3.0178	40
30	.3173	.9483	.3346	2.9887	30
40	.3201	.9474	.3378	2.9600	20
50	.3228	.9465	.3411	2.9319	10
19° 00′	0.3256	0.9455	0.3443	2.9042	71° 00′
10	.3283	.9446	.3476	2.8770	50
20	.3311	.9436	.3508	2.8502	40
30	.3338	.9426	.3541	2.8239	30
40	.3365	.9417	.3574	2.7980	20
50	.3393	.9407	.3607	2.7725	10
20° 00′	0.3420	0.9397	0.3640	2.7475	70° 00′
10	.3448	.9387	.3673	2.7228	50
20	.3475	.9377	.3706	2.6985	40
30	.3502	.9367	.3739	2.6746	30
40	.3529	.9356	.3772	2.6511	20
50	.3557	.9346	.3805	2.6279	10
21° 00′	0.3584	0.9336	0.3839	2.6051	69° 00′
10	.3611	.9325	.3872	2.5826	50
20	.3638	.9315	.3906	2.5605	40
30	.3665	.9304	.3939	2.5386	30
40	.3692	.9293	.3973	2.5172	20
50	.3719	.9283	.4006	2.4960	10
22° 00′	0.3746	0.9272	0.4040	2.4751	68° 00′
10	.3773	.9261	.4074	2.4545	50
20	.3800	.9250	.4108	2.4342	40
30	.3827	.9239	.4142	2.4142	30
40	.3854	.9228	.4176	2.3945	20
50	.3881	.9216	.4210	2.3750	10
23° 00′	0.3907	0.9205	0.4245	2.3559	67° 00′
10	.3934	.9194	.4279	2.3369	50
20	.3961	.9182	.4314	2.3183	40
30	.3987	.9171	.4348	2.2998	30
40	.4014	.9159	.4383	2.2817	20
50	.4041	.9147	.4417	2.2637	10
24° 00′	0.4067	0.9135	0.4452	2.2460	66° 00′
10	.4094	.9124	.4487	2.2286	50
20	.4120	.9112	.4522	2.2113	40
30	.4147	.9100	.4557	2.1943	30
40	.4173	.9088	.4592	2.1775	20
50	.4200	.9075	.4628	2.1609	10
25° 00	0.4226	0.9063	0.4663	2.1445	65° 00′
10	.4253	.9051	.4699	2.1283	50
20	.4279	.9038	.4734	2.1123	40
30	.4305	.9026	.4770	2.0965	30
40	.4331	.9013	.4806	2.0809	20
50	.4358	.9001	.4841	2.0655	10
26° 00′	0.4384	0.8988	0.4877	2.0503	64° 00′
10	.4410	.8975	.4913	2.0353	50
20	.4436	.8962	.4950	2.0204	40
30	.4462	.8949	.4986	2.0057	30
40	.4488	.8936	.5022	1.9912	20
50	.4514	.8923	.5059	1.9768	10
27° 00′	0.4540	0.8910	0.5095	1.9626	63° 00′
Degrees.	Cos.	Sin.	Cot.	Tan.	Degrees.

NATURAL SINES, COSINES, TANGENTS AND COTANGENTS (Continued)

Degrees.	Sin.	Cos.	Tan.	Cot.	Degrees.
27° 00	0.4540	0.8910	0.5095	1.9626	63° 00′
10	.4566	.8897	.5132	1.9486	50
20	.4592	.8884	.5169	1.9347	40
30	.4617	.8870	.5206	1.9210	30
40	.4643	.8857	.5243	1.9074	20
50	.4669	.8843	.5280	1.8940	10
28° 00′	0.4695	0.8829	0.5317	1.8807	62° 00′
10	.4720	.8816	.5354	1.8676	50
20	.4746	.8802	.5392	1.8546	40
30	.4772	.8788	.5430	1.8418	30
40	.4797	.8774	.5467	1.8291	20
50	.4823	.8760	.5505	1.8165	10
29° 00′	0.4848	0.8746	0.5543	1.8040	61° 00′
10	.4874	.8732	.5581	1.7917	50
20	.4899	.8718	.5619	1.7796	40
30	.4924	.8704	.5658	1.7675	30
40	.4950	.8689	.5696	1.7556	20
50	.4975	.8675	.5735	1.7437	10
30° 00′	0.5000	0.8660	0.5774	1.7321	60° 00′
10	.5025	.8646	.5812	1.7205	50
20	.5050	.8631	.5851	1.7090	40
30	.5075	.8616	.5890	1.6977	30
40	.5100	.8601	.5930	1.6864	20
50	.5125	.8587	.5969	1.6753	10
31° 00′	0.5150	0.8572	0.6009	1.6643	59° 00′
10	.5175	.8557	.6048	1.6534	50
20	.5200	.8542	.6088	1.6426	40
30	.5225	.8526	.6128	1.6319	30
40	.5250	.8511	.6168	1.6212	20
50	.5275	.8496	.6208	1.6107	10
32° 00′	0.5299	0.8480	0.6249	1.6003	58° 00′
10	.5324	.8465	.6289	1.5900	50
20	.5348	.8450	.6330	1.5798	40
30	.5373	.8434	.6371	1.5697	30
40	.5398	.8418	.6412	1.5597	20
50	.5422	.8403	.6453	1.5497	10
33° 00′	0.5446	0.8387	0.6494	1.5399	57° 00′
10	.5471	.8371	.6536	1.5301	50
20	.5495	.8355	.6577	1.5204	40
30	.5519	.8339	.6619	1.5108	30
40	.5544	.8323	.6661	1.5013	20
50	.5568	.8307	.6703	1.4919	10
34° 00′	0.5592	0.8290	0.6745	1.4826	56° 00′
10	.5616	.8274	.6787	1.4733	50
20	.5640	.8258	.6830	1.4641	40
30	.5664	.8241	.6873	1.4550	30
40	.5688	.8225	.6916	1.4460	20
50	.5712	.8208	.6959	1.4370	10
35° 00′	0.5736	0.8192	0.7002	1.4281	55° 00′
10	.5760	.8175	.7046	1.4193	50
20	.5783	.8158	.7089	1.4106	40
30	.5807	.8141	.7133	1.4019	30
40	.5831	.8124	.7177	1.3934	20
50	.5854	.8107	.7221	1.3848	10
36° 00′	0.5878	0.8090	0.7265	1.3764	54° 00′
Degrees.	Cos.	Sin.	Cot.	Tan.	Degrees.

NATURAL SINES, COSINES, TANGENTS AND TANGENTS (Continued)

Degrees.	Sin.	Cos.	Tan.	Cot.	Degrees.
36° 00′	0.5878	0.8090	0.7265	1.3764	54° 00′
10	.5901	.8073	.7310	1.3680	50
20	.5925	.8056	.7355	1.3597	40
30	.5948	.8039	.7400	1.3514	30
40	.5972	.8021	.7445	1.3432	20
50	.5995	.8004	.7490	1.3351	10
37° 00′	.6018	.7986	.7536	1.3270	53° 00′
10	.6041	.7969	.7581	1.3190	50
20	.6065	.7951	.7627	1.3111	40
30	.6088	.7934	.7673	1.3032	30
40	.6111	.7916	.7720	1.2954	20
50	.6134	.7898	.7766	1.2876	10
38° 00′	0.6157	0.7880	0.7813	1.2799	52° 00′
10	.6180	.7862	.7860	1.2723	50
20	.6202	.7844	.7907	1.2647	40
30	.6225	.7826	.7954	1.2572	30
40	.6248	.7808	.8002	1.2497	20
50	.6271	.7790	.8050	1.2423	10
39° 00′	0.6293	0.7771	0.8098	1.2349	51° 00′
10	.6316	.7753	.8146	1.2276	50
20	.6338	.7735	.8195	1.2203	40
30	.6361	.7716	.8243	1.2131	30
40	.6383	.7698	.8292	1.2059	20
50	.6406	.7679	.8342	1.1988	10
40° 00′	0.6428	0.7660	0.8391	1.1918	50° 00′
10	.6450	.7642	.8441	1.1847	50
20	.6472	.7623	.8491	1.1778	40
30	.6494	.7604	.8541	1.1708	30
40	.6517	.7585	.8591	1.1640	20
50	.6539	.7566	.8642	1.1571	10
41° 00′	0.6561	0.7547	0.8693	1.1504	49° 00′
10	.6583	.7528	.8744	1.1436	50
20	.6604	.7509	.8796	1.1369	40
30	.6626	.7490	.8847	1.1303	30
40	.6648	.7470	.8899	1.1237	20
50	.6670	.7451	.8952	1.1171	10
42° 00′	0.6691	0.7431	0.9004	1.1106	48° 00′
10	.6713	.7412	.9057	1.1041	50
20	.6734	.7392	.9110	1.0977	40
30	.6756	.7373	.9163	1.0913	30
40	.6777	.7353	.9217	1.0850	20
50	.6799	.7333	.9271	1.0786	10
43° 00′	0.6820	0.7314	0.9325	1.0724	47° 00′
10	.6841	.7294	.9380	1.0661	50
20	.6862	.7274	.9435	1.0599	40
30	.6884	.7254	.9490	1.0538	30
40	.6905	.7234	.9545	1.0477	20
50	.6926	.7214	.9601	1.0416	10
44° 00′	0.6947	0.7193	0.9657	1.0355	46° 00′
10	.6967	.7173	.9713	1.0295	50
20	.6988	.7163	.9770	1.0235	40
30	.7009	.7133	.9827	1.0176	30
40	.7030	.7112	.9884	1.0117	20
50	.7050	.7092	.9942	1.0058	10
45° 00′	0.7071	0.7071	1.0000	1.0000	45° 00′
Degrees.	Cos.	Sin.	Cot.	Tan.	Degrees.

LOGARITHMS OF THE TRIGONOMETRICAL FUNCTIONS

Degrees.	Log sin	Log cos	Log tan	Log cot	Degrees.
0° 00′	∞	0.0000	∞	∞	90° 00′
10	7.4637	.0000	7.4637	2.5363	50
20	.7648	.0000	.7648	.2352	40
30	.9408	.0000	.9409	.0591	30
40	8.0658	.0000	8.0658	1.9342	20
50	.1627	.0000	.1627	.8373	10
1° 00′	8.2419	9.9999	8.2419	1.7581	89° 00′
10	.3088	.9999	.3089	.6911	50
20	.3668	.9999	.3669	.6331	40
30	.4179	.9999	.4181	.5819	30
40	.4637	.9998	.4638	.5362	20
50	.5050	.9998	.5053	.4947	10
2° 00′	8.5428	9.9997	8.5431	1.4569	88° 00′
10	.5776	.9997	.5779	.4221	50
20	.6097	.9996	.6101	.3899	40
30	.6397	.9996	.6401	.3599	30
40	.6677	.9995	.6682	.3318	20
50	.6940	.9995	.6945	.3055	10
3° 00′	8.7188	9.9994	8.7194	1.2806	87° 00′
10	.7423	.9993	.7429	.2571	50
20	.7645	.9993	.7652	.2348	40
30	.7857	.9992	.7865	.2135	30
40	.8059	.9991	.8067	.1933	20
50	.8251	.9990	.8261	.1739	10
4° 00′	8.8436	9.9989	8.8446	1.1554	86° 00′
10	.8613	.9989	.8624	.1376	50
20	.8783	.9988	.8795	.1205	40
30	.8946	.9987	.8960	.1040	30
40	.9104	.9986	.9118	.0882	20
50	.9256	.9985	.9272	.0728	10
5° 00′	8.9403	9.9983	8.9420	1.0580	85° 00′
10	.9545	.9982	.9563	.0437	50
20	.9682	.9981	.9701	.0299	40
30	.9816	.9980	.9836	.0164	30
40	.9945	.9979	.9966	.0034	20
50	9.0070	.9977	9.0093	0.9907	10
6° 00′	9.0192	9.9976	9.0216	0.9784	84° 00′
10	.0311	.9975	.0336	.9664	50
20	.0426	.9973	.0453	.9547	40
30	.0539	.9972	.0567	.9433	30
40	.0648	.9971	.0678	.9322	20
50	.0755	.9969	.0786	.9214	10
7° 00′	9.0859	9.9968	9.0891	0.9109	83° 00′
10	.0961	.9966	.0995	.9005	50
20	.1060	.9964	.1096	.8904	40
30	.1157	.9963	.1194	.8806	30
40	.1252	.9961	.1291	.8709	20
50	.1345	.9959	.1385	.8615	10
8° 00′	9.1436	9.9958	9.1478	0.8522	82° 00′
10	.1525	.9956	.1569	.8431	50
20	.1612	.9954	.1658	.8342	40
30	.1697	.9952	.1745	.8255	30
40	.1781	.9950	.1831	.8169	20
50	.1863	.9948	.1915	.8085	10
9° 00′	9.1943	9.9946	9.1997	0.8003	81° 00′
Degrees.	Log cos	Log sin	Log cot	Log tan	Degrees.

LOGARITHMS OF THE TRIGONOMETRICAL FUNCTIONS
(Continued)

Degrees.	Log sin	Log cos	Log tan	Log cot	Degrees.
9° 00′	9.1943	9.9946	9.1997	0.8003	81° 00′
10	.2022	.9944	.2078	.7922	50
20	.2100	.9942	.2158	.7842	40
30	.2176	.9940	.2236	.7764	30
40	.2251	.9938	.2313	.7687	20
50	.2324	.9936	.2389	.7611	10
10° 00′	9.2397	9.9934	9.2463	0.7537	80° 00′
10	.2468	.9931	.2536	.7464	50
20	.2538	.9929	.2609	.7391	40
30	.2606	.9927	.2680	.7320	30
40	.2674	.9924	.2750	.7250	20
50	.2740	.9922	.2819	.7181	10
11° 00′	9.2806	9.9919	9.2887	0.7113	79° 00′
10	.2870	.9917	.2953	.7047	50
20	.2934	.9914	.3020	.6980	40
30	.2997	.9912	.3085	.6915	30
40	.3058	.9909	.3149	.6851	20
50	.3119	.9907	.3212	.6788	10
12° 00′	9.3179	9.9904	9.3275	0.6725	78° 00′
10	.3238	.9901	.3336	.6664	50
20	.3296	.9899	.3397	.6603	40
30	.3353	.9896	.3458	.6542	30
40	.3410	.9893	.3517	.6483	20
50	.3466	.9890	.3576	.6424	10
13° 00′	9.3521	9.9887	9.3634	0.6366	77° 00′
10	.3575	.9984	.3691	.6309	50
20	.3629	.9881	.3748	.6252	40
30	.3682	.9878	.3804	.6196	30
40	.3734	.9875	.3859	.6141	20
50	.3786	.9872	.3914	.6086	10
14° 00′	9.3837	9.9869	9.3968	0.6032	76° 00
10	.3887	.9866	.4021	.5979	50
20	.3937	.9863	.4074	.5926	40
30	.3986	.9859	.4127	.5873	30
40	.4035	.9856	.4178	.5822	20
50	.4083	.9853	.4230	.5770	10
15° 00′	9.4130	9.9849	9.4281	0.5719	75° 00′
10	.4177	.9846	.4331	.5669	50
20	.4223	.9843	.4381	.5619	40
30	.4269	.9839	.4430	.5570	30
40	.4314	.9836	.4479	.5521	20
50	.4359	.9832	.4527	.5473	10
16° 00′	9.4403	9.9828	9.4575	0.5425	74° 00′
10	.4447	.9825	.4622	.5378	50
20	.4491	.9821	.4669	.5331	40
30	.4533	.9817	.4716	.5284	30
40	.4576	.9814	.4762	.5238	20
50	.4618	.9810	.4808	.5192	10
17° 00′	9.4659	9.9806	9.4853	0.5147	73° 00′
10	.4700	.9802	.4898	.5102	50
20	.4741	.9798	.4943	.5057	40
30	.4781	.9794	.4987	.5013	30
40	.4821	.9790	.5031	.4969	20
50	.4861	.9786	.5075	.4925	10
18° 00′	9.4900	9.9782	9.5118	0.4882	72° 00′
Degrees.	Log cos	Log sin	Log cot	Log tan	Degrees.

LOGARITHMS OF THE TRIGONOMETRICAL FUNCTIONS (Continued)

Degrees.	Log sin	Log cos	Log tan	Log cot	Degrees.
18° 00′	9.4900	9.9782	9.5118	0.4882	72° 00′
10	.4939	.9778	.5161	.4839	50
20	.4977	.9774	.5203	.4797	40
30	.5015	.9770	.5245	.4755	30
40	.5052	.9765	.5287	.4713	20
50	.5090	.9761	.5329	.4671	10
19° 00′	9.5126	9.9757	9.5370	0.4630	71° 00′
10	.5163	.9752	.5411	.4589	50
20	.5199	.9748	.5451	.4549	40
30	.5235	.9743	.5491	.4509	30
40	.5270	.9739	.5531	.4469	20
50	.5306	.9734	.5571	.4429	10
20° 00′	9.5341	9.9730	9.5611	0.4389	70° 00′
10	.5375	.9725	.5650	.4350	50
20	.5409	.9721	.5689	.4311	40
30	.5443	.9716	.5727	.4273	30
40	.5477	.9711	.5766	.4234	20
50	.5510	.9706	.5804	.4196	10
21° 00′	9.5543	9.9702	9.5842	0.4158	69° 00′
10	.5576	.9697	.5879	.4121	50
20	.5609	.9692	.5917	.4083	40
30	.5641	.9687	.5954	.4046	30
40	.5673	.9682	.5991	.4009	20
50	.5704	.9677	.6028	.3972	10
22° 00′	9.5736	9.9672	9.6064	0.3936	68° 00′
10	.5767	.9667	.6100	.3900	50
20	.5798	.9661	.6136	.3864	40
30	.5828	.9656	.6172	.3828	30
40	.5859	.9651	.6208	.3792	20
50	.5889	.9646	.6243	.3757	10
23° 00′	9.5919	9.9640	9.6279	0.3721	67° 00′
10	.5948	.9635	.6314	.3686	50
20	.5978	.9629	.6348	.3652	40
30	.6007	.9624	.6383	.3617	30
40	.6036	.9618	.6417	.3583	20
50	.6065	.9613	.6452	.3548	10
24° 00′	9.6093	9.9607	9.6486	0.3514	66° 00′
10	.6121	.9602	.6520	.3480	50
20	.6149	.9596	.6553	.3447	40
30	.6177	.9590	.6587	.3413	30
40	.6205	.9584	.6620	.3380	20
50	.6232	.9579	.6654	.3346	10
25° 00′	9.6259	9.9573	9.6687	0.3313	65° 00′
10	.6286	.9567	.6720	.3280	50
20	.6313	.9561	.6752	.3248	40
30	.6340	.9555	.6785	.3215	30
40	.6366	.9549	.6817	.3183	20
50	.6392	.9543	.6850	.3150	10
26° 00′	9.6418	9.9537	9.6882	0.3118	64° 00′
10	.6444	.9530	.6914	.3086	50
20	.6470	.9524	.6946	.3054	40
30	.6495	.9518	.6977	.3023	30
40	.6521	.9512	.7009	.2991	20
50	.6546	.9505	.7040	.2960	10
27° 00′	9.6570	9.9499	9.7072	0.2928	63° 00′
Degrees.	Log cos	Log sin	Log cot	Log tan	Degrees.

LOGARITHMS OF THE TRIGONOMETRICAL FUNCTIONS
(Continued)

Degrees.	Log sin	Log cos	Log tan	Log cot	Degrees.
27° 00′	9.6570	9.9499	9.7072	0.2928	63° 00′
10	.6595	.9492	.7103	.2897	50
20	.6620	.9486	.7134	.2866	40
30	.6644	.9479	.7165	.2835	30
40	.6668	.9473	.7196	.2804	20
50	.6692	.9466	.7226	.2774	10
28° 00′	9.6716	9.9459	9.7257	0.2743	62° 00′
10	.6740	.8453	.7287	.2713	50
20	.6763	.9446	.7317	.2683	40
30	.6787	.9439	.7348	.2652	30
40	.6810	.9432	.7378	.2622	20
50	.6833	.9425	.7408	.2592	10
29° 00′	9.6856	9.9418	9.7438	0.2562	61° 00′
10	.6878	.9411	.7467	.2533	50
20	.6901	.9404	.7497	.2503	40
30	.6923	.9397	.7526	.2474	30
40	.6946	.9390	.7556	.2444	20
50	.6968	.9383	.7585	.2415	10
30° 00′	9.6990	9.9375	9.7614	0.2386	60° 00′
10	.7012	.9368	.7644	.2356	50
20	.7033	.9361	.7673	.2327	40
30	.7055	.9353	.7701	.2299	30
40	.7076	.9346	.7730	.2270	20
50	.7097	.9338	.7759	.2241	10
31° 00′	9.7118	9.9331	9.7788	0.2212	59° 00′
10	.7139	.9323	.7816	.2184	50
20	.7160	.9315	.7845	.2155	40
30	.7181	.9308	.7873	.2127	30
40	.7201	.9300	.7902	.2098	20
50	.7222	.9292	.7930	.2070	10
32° 00′	9.7242	9.9284	9.7958	0.2042	58° 00′
10	.7262	.9276	.7986	.2014	50
20	.7282	.9268	.8014	.1986	40
30	.7302	.9260	.8042	.1958	30
40	.7322	.9252	.8070	.1930	20
50	.7342	.9244	.8097	.1903	10
33° 00	9.7361	9.9236	9.8125	0.1875	57° 00′
10	.7380	.9228	.8153	.1847	50
20	.7400	.9219	.8180	.1820	40
30	.7419	.9211	.8208	.1792	30
40	.7438	.9203	.8235	.1765	20
50	.7457	.9194	.8263	.1737	10
34° 00′	9.7476	9.9186	9.8290	0.1710	56° 00′
10	.7494	.9177	.8317	.1683	50
20	.7513	.9169	.8344	.1656	40
30	.7531	.9160	.8371	.1629	30
40	.7550	.9151	.8398	.1602	20
50	.7568	.9142	.8425	.1575	10
35° 00′	9.7586	9.9134	9.8452	0.1548	55° 00′
10	.7604	.9125	.8479	.1521	50
20	.7622	.9116	.8506	.1494	40
30	.7640	.9107	.8533	.1467	30
40	.7657	.9098	.8559	.1441	20
50	.7675	.9089	.8586	.1414	10
36° 00′	9.7692	9.9080	9.8613	0.1387	54° 00′
Degrees.	Log cos	Log sin	Log cot	Log tan	Degrees.

LOGARITHMS OF THE TRIGONOMETRICAL FUNCTIONS (Continued)

Degrees.	Log sin	Log cos	Log tan	Log cot	Degrees.
36° 00′	9.7692	9.9080	9.8613	0.1387	54° 00′
10	.7710	.9070	.8639	.1361	50
20	.7727	.9061	.8666	.1334	40
30	.7744	.9052	.8692	.1308	30
40	.7761	.9042	.8718	.1282	20
50	.7778	.9033	.8745	.1255	10
37° 00′	9.7795	9.9023	9.8771	0.1229	53° 00′
10	.7811	.9014	.8797	.1203	50
20	.7828	.9004	.8824	.1176	40
30	.7844	.8995	.8850	.1150	30
40	.7861	.8985	.8876	.1124	20
50	.7877	.8975	.8902	.1098	10
38° 00′	9.7893	9.8965	9.8928	0.1072	52° 00′
10	.7910	.8955	.8954	.1046	50
20	.7926	.8945	.8980	.1020	40
30	.7941	.8935	.9006	.0994	30
40	.7957	.8925	.9032	.0968	20
50	.7973	.8915	.9058	.0942	10
39° 00′	9.7989	9.8905	9.9084	0.0916	51° 00′
10	.8004	.8895	.9110	.0890	50
20	.8020	.8884	.9135	.0865	40
30	.8035	.8874	.9161	.0839	30
40	.8050	.8864	.9187	.0813	20
50	.8066	.8853	.9212	.0788	10
40° 00′	9.8081	9.8843	9.9238	0.0762	50° 00′
10	.8096	.8832	.9264	.0736	50
20	.8111	.8821	.9289	.0711	40
30	.8125	.8810	.9315	.0685	30
40	.8140	.8800	.9341	.0659	20
50	.8155	.8789	.9366	.0634	10
41° 00′	9.8169	9.8778	9.9392	0.0608	49° 00′
10	.8184	.8767	.9417	.0583	50
20	.8198	.8756	.9443	.0557	40
30	.8213	.8745	.9468	.0532	30
40	.8227	.8733	.9494	.0506	20
50	.8241	.8722	.9519	.0481	10
42° 00′	9.8255	9.8711	9.9544	0.0456	48° 00′
10	.8269	.8699	.9570	.0430	50
20	.8283	.8688	.9595	.0405	40
30	.8297	.8676	.9621	.0379	30
40	.8311	.8665	.9646	.0354	20
50	.8324	.8653	.9671	.0329	10
43° 00′	9.8338	9.8641	9.9697	0.0303	47° 00′
10	.8351	.8629	.9722	.0278	50
20	.8365	.8618	.9747	.0253	40
30	.8378	.8606	.9773	.0228	30
40	.8391	.8594	.9798	.0202	20
50	.8405	.8582	.9823	.0177	10
44° 00′	9.8418	9.8569	9.9848	0.0152	46° 00′
10	.8431	.8557	.9874	.0126	50
20	.8444	.8545	.9899	.0101	40
30	.8457	.8532	.9927	.0076	30
40	.8469	.8520	.9949	.0051	20
50	.8482	.8507	.9975	.0025	10
45° 00′	9.8495	9.8495	0.0000	0.0000	45° 00′
Degrees.	Log cos	Log sin	Log cot	Log tan	Degrees.

NUMERICAL TABLE

Reciprocals, Powers and Roots of Numbers, Circumferences and Areas of Circles

n	$1/n$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	Circum. of circle πn	Area of circle $\frac{1}{4}\pi n^2$
1	1.	1	1	1.	1.	3.14	0.79
2	.50000	4	8	1.414	1.260	6.28	3.14
3	.33333	9	27	1.732	1.442	9.42	7.07
4	.25000	16	64	2.000	1.587	12.57	12.6
5	.20000	25	125	2.236	1.710	15.71	19.6
6	.16667	36	216	2.449	1.817	18.85	28.3
7	.14286	49	343	2.646	1.913	21.99	38.5
8	.12500	64	512	2.828	2.000	25.13	50.3
9	.11111	81	729	3.000	2.080	28.27	63.6
10	.10000	100	1000	3.162	2.154	31.42	78.5
11	.09091	121	1331	3.317	2.224	34.56	95.0
12	.08333	144	1728	3.464	2.289	37.70	113.1
13	.07692	169	2197	3.606	2.351	40.84	132.7
14	.07143	196	2744	3.742	2.410	43.98	153.9
15	.06667	225	3375	3.873	2.466	47.12	176.7
16	.06250	256	4096	4.000	2.520	50.27	201.1
17	.05882	289	4913	4.123	2.571	53.41	227.0
18	.05556	324	5832	4.243	2.621	56.55	254.5
19	.05263	361	6859	4.359	2.668	59.69	283.5
20	.05000	400	8000	4.472	2.714	62.83	314.2
21	.04762	441	9261	4.583	2.759	65.97	346.4
22	.04545	484	10648	4.690	2.802	69.12	380.1
23	.04348	529	12167	4.796	2.844	72.26	415.5
24	.04167	576	13824	4.899	2.884	75.40	452.4
25	.04000	625	15625	5.000	2.924	78.54	490.9
26	.03846	676	17576	5.099	2.962	81.68	530.9
27	.03704	729	19683	5.196	3.000	84.82	572.6
28	.03571	784	21952	5.291	3.037	87.96	615.8
29	.03448	841	24389	5.385	3.072	91.11	660.5
30	.03333	900	27000	5.477	3.107	94.25	706.9
31	.03226	961	29791	5.568	3.141	97.39	754.8
32	.03125	1024	32768	5.657	3.175	100.53	804.2
33	.03030	1089	35937	5.745	3.208	103.67	855.3
34	.02941	1156	39304	5.831	3.240	106.81	907.9
35	.02857	1225	42875	5.916	3.271	109.96	962.0
36	.02778	1296	46656	6.000	3.302	113.10	1018.
37	.02703	1369	50653	6.083	3.332	116.24	1075.
38	.02632	1444	54872	6.164	3.362	119.38	1134.
39	.02564	1521	59319	6.245	3.391	122.52	1195.
40	.02500	1600	64000	6.325	3.420	125.66	1257.
41	.02439	1681	68921	6.403	3.448	128.81	1320.
42	.02381	1764	74088	6.481	3.476	131.95	1385.
43	.02326	1849	79507	6.557	3.503	135.09	1452.
44	.02273	1936	85184	6.633	3.530	138.23	1521.
45	.02222	2025	91125	6.708	3.557	141.37	1590.
46	.02174	2116	97336	6.782	3.583	144.51	1662.
47	.02128	2209	103823	6.856	3.609	147.65	1735.
48	.02083	2304	110592	6.928	3.634	150.80	1810.
49	.02041	2401	117649	7.000	3.659	153.94	1886.
50	.02000	2500	125000	7.071	3.684	157.08	1963.

NUMERICAL TABLE (Continued)

RECIPROCALS, POWERS AND ROOTS OF NUMBERS, CIRCUMFERENCES AND AREAS OF CIRCLES (Continued)

n	$1/n$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$	Circum. of circle πn	Area of circle. $\frac{1}{4}\pi n^2$
51	.01961	2601	132651	7.141	3.708	160.22	2043.
52	.01923	2704	140608	7.211	3.733	163.36	2124.
53	.01887	2809	148877	7.280	3.756	166.50	2206.
54	.01852	2916	157464	7.348	3.780	169.65	2290.
55	.01818	3025	166375	7.416	3.803	172.79	2376.
56	.01786	3136	175616	7.483	3.826	175.93	2463.
57	.01754	3249	185193	7.550	3.849	179.07	2552.
58	.01724	3364	195112	7.616	3.871	182.21	2642.
59	.01695	3481	205379	7.681	3.893	185.35	2734.
60	.01667	3600	216000	7.746	3.915	188.50	2827.
61	.01639	3721	226981	7.810	3.936	191.64	2922.
62	.01613	3844	238328	7.874	3.958	194.78	3019.
63	.01587	3969	250047	7.937	3.979	197.92	3117.
64	.01563	4096	262144	8.000	4.000	201.06	3217.
65	.01538	4225	274625	8.062	4.021	204.20	3318.
66	.01515	4356	287496	8.124	4.041	207.35	3421.
67	.01493	4489	300763	8.185	4.062	210.49	3526.
68	.01471	4624	314432	8.246	4.082	213.63	3632.
69	.01449	4761	328509	8.307	4.102	216.77	3739.
70	.01429	4900	343000	8.367	4.121	219.91	3848.
71	.01408	5041	357911	8.426	4.141	223.05	3959.
72	.01389	5184	373248	8.485	4.160	226.19	4072.
73	.01370	5329	389017	8.544	4.179	229.34	4185.
74	.01351	5476	405224	8.602	4.198	232.48	4301.
75	.01333	5625	421875	8.660	4.217	235.62	4418.
76	.01316	5776	438976	8.718	4.236	238.76	4536.
77	.01299	5929	456533	8.775	4.254	241.90	4657.
78	.01282	6084	474552	8.832	4.273	245.04	4778.
79	.01266	6241	493039	8.888	4.291	248.19	4902.
80	.01250	6400	512000	8.944	4.309	251.33	5027.
81	.01235	6561	531441	9.000	4.327	254.47	5153.
82	.01220	6724	551368	9.055	4.344	257.61	5281.
83	.01205	6889	571787	9.110	4.362	260.75	5411.
84	.01191	7056	592704	9.165	4.380	263.89	5542.
85	.01177	7225	614125	9.220	4.397	267.04	5675.
86	.01163	7396	636056	9.274	4.414	270.18	5809.
87	.01149	7569	658503	9.327	4.431	273.32	5945.
88	.01136	7744	681472	9.381	4.448	276.46	6082.
89	.01124	7921	704969	9.434	4.465	279.60	6221.
90	.01111	8100	729000	9.487	4.481	282.74	6362.
91	.01099	8281	753571	9.539	4.498	285.88	6504.
92	.01087	8464	778688	9.592	4.514	289.03	6648.
93	.01075	8649	804357	9.644	4.531	292.17	6793.
94	.01064	8836	830584	9.695	4.547	295.31	6940.
95	.01053	9025	857375	9.747	4.563	298.45	7088.
96	.01042	9216	884736	9.798	4.579	301.59	7238.
97	.01031	9409	912673	9.849	4.595	304.73	7390.
98	.01020	9604	941192	9.899	4.610	307.88	7543.
99	.01010	9801	970299	9.950	4.626	311.02	7698.
100	.01000	10000	1000000	10.000	4.642	314.16	7854.

NUMERICAL CONSTANTS

$$\pi = 3.14159$$

$$\log \pi = 0.497150$$

$4\pi = 12.56637$	$\log 4\pi = 1.099210$
$\frac{\pi}{2} = 1.57080$	$\log \frac{\pi}{2} = 0.196120$
$\frac{\pi}{3} = 1.04720$	$\log \frac{\pi}{3} = 0.020029$
$\frac{4}{3}\pi = 4.18879$	$\log \frac{4}{3}\pi = 0.622089$
$\frac{\pi}{4} = 0.78540$	$\log \frac{\pi}{4} = 9.895090-10$
$\frac{1}{\pi} = 0.31831$	$\log \frac{1}{\pi} = 9.502850-10$
$\pi^2 = 9.86960$	$\log \pi^2 = 0.994300$
$\frac{1}{\pi^2} = 0.10132$	$\log \frac{1}{\pi^2} = 9.005700-10$
$\sqrt{\pi} = 1.77245$	$\log \sqrt{\pi} = 0.248575$
$\frac{1}{\sqrt{\pi}} = 0.56419$	$\log \frac{1}{\sqrt{\pi}} = 9.751425-10$
$\sqrt[3]{\pi} = 1.46459$	$\log \sqrt[3]{\pi} = 0.165717$

BASE OF NATURAL LOGARITHMS

$$e = 2.71828$$

$$\log_{10} e = 0.434294$$

Natural log of $x = \log_e x = 2.30259 \log_{10} x$.

APPARATUS LISTS

LIST OF APPARATUS AND MATERIAL FOR EXPERIMENTS IN CHEMISTRY

Beakers, nest of 5 (3 to 20 oz.)
Blowpipe, plain, 8 inch.
Bottles, W. M., two 8 oz.
Bottles, N. M., two 8 oz.
Burette, 25 cc. 1-10ths.
Corks, 2 dozen, assorted.
Cork Borers, set 1-3.
Corkscrew, wood handle.
Crucibles, Hessian, 2 nests large 5's.
Crucible Tongs, 9 in.
Deflagrating Spoon, brass, ½ inch.
Dish, Crystallizing, 4 inch.
Dish, Evaporating, 2 oz.
Dish, Evaporating, 6 oz.
Dish, Lead, 3 inch.
File, Triangular, 5 inch.
File, round, 5 inch.
Filter Paper, 1 pkg., 5 inch.
Flasks, F. B., two 4 oz.
Flask, F. B., 8 oz.
Flask, F. B., 16 oz.
Funnel, glass, 2½ inch.
Funnel, glass, 4 inch.
Gas Bag, with stopcock, 1 gal.
Gas Generating Flask, quart.
Glass Tubing, 1 lb., 3-16-¼.
Graduate, conical, 100 cc.
Hand Balance, 5-inch beam, with weights.
Hydrometer, for heavy liquids.
Jar for Hydrometer, 12x2½.
Jar, Specie, for deflagration, two 1-quart size.
Lamp, Alcohol, 4 oz.
Mortar, Wedgewood, 3¾ inch.
Pipette, Volumetric, 5 cc.
Pipette, Volumetric, 10 cc.
Pneumatic Trough, student's.
Reagent Bottles, 1 set of 24.
Retort, glass, plain, 16 oz.
Receiver for Retort, 8 oz.
Reduction Tube for reducing metallic oxides.
Retort Stand, 3 ring.
Rubber Tubing, 6 feet, ¼ inch.
Sand Bath, 4 inch.
Spatula, steel, 4 inch.
Stirring Rods, 3, 5x3-16.
Test Glass, 2 oz.
Test Tubes, 2 dozen, assorted.
Test Tubes, 1 dozen, 6x¾.
Test Tube Brush, sponge end.
Test Tube Holder, wire.
Test Tube Support, 13 tubes with drying pins.
Thermometer Paper Scale, 110° C.
Thistle Tubes, two.
U Tube, 6 inch.
Watch Glass, 2½ inch.
Watch Springs, for burning in oxygen, ½ dozen.
Wire Gauze, 4x4.
Woulff Bottle, 3 neck, pint.
½ lb. Acetic Acid.
1 lb. Hydrochloric Acid.
1 lb. Nitric Acid.
1 oz. Oxalic Acid.
2 lbs. Sulphuric Acid.
1 oz. Tartaric Acid.
1 oz. Ammonium Carbonate.
2 oz. Ammonium Chloride.
½ lb. Ammonium Hydrate.
1 oz. Ammonium Nitrate.
1 oz. Ammonium Sulphide.
½ pt. Alcohol Methyl.
2 oz. Alum.
2 oz. Animal Charcoal.

1 oz. Antimony.
1 oz. Arsenic Trioxide.
1 oz. Barium Chloride.
1 oz. Barium Nitrate.
1 oz. Borax.
¼ lb. Calcium Carbonate (marble).
2 oz. Calcium Chloride.
2 oz. Calcium Fluoride.
¼ lb. Calcium Sulphate.
1 oz. Carbon Bisulphide.
1 oz. Cobalt Nitrate.
4 oz. Copper Sulphate.
2 oz. Ether.
2 oz. Ferrous Sulphate.
8 oz. Ferrous Sulphide.
½ oz. Gall Nuts (powdered).
⅛ oz. Gun Cotton.
¼ oz. Iodine.
2 oz. Galena.
1 oz. Lead Acetate.
4 oz. Lead Oxide (red).
4 oz. Lead Monoxide
½ oz. Litmus (best cubes).
12 in. Magnesium Ribbon.
4 oz. Magnesium Sulphate.
1 lb. Manganese Dioxide (powdered).
4 oz. Mercury.
½ oz. Mercuric Chloride.
½ oz. Mercuric Oxide.
12 in. Platinum Wire.
½ oz. Phosphorus.
⅛ oz. Potassium (metallic).
½ lb. Potassium Bichromate.
1 oz. Potassium Bromide.
2 oz. Potassium Carbonate.
½ lb. Potassium Chlorate.
1 oz. Potassium Chromate.
½ oz. Potassium Cyanide.
2 oz. Potassium Ferricyanide.
2 oz. Potassium Ferrocyanide.
1 oz. Potassium Hydrate (sticks).
¼ oz. Potassium Iodide.
2 oz. Potassium Nitrate.
½ oz. Potassium Permanganate.
1 oz. Potassium Sulphate.
⅛ oz. Silver Nitrate.
¼ oz. Sodium (metallic).
1 oz. Sodium Acetate.
4 oz. Sodium Carbonate.
2 oz. Sodium Hydrate (sticks).
2 oz. Sodium Hyposulphite.
2 oz. Sodium Sulphate.
1 oz. Sodium Phosphate.
1 oz. Strontium Nitrate.
½ lb. Sulphur Roll.
½ lb. Zinc for making Hydrogen.

LIST OF APPARATUS AND MATERIAL FOR EXPERIMENTS IN PHYSICS

General Equipment

Interchangeable supports, bases, rods, clamps, arms, rings, etc.
Balances, platform scales and enclosed, sensitive balance, with appropriate weights.

Barometer.
Water Still.
Cells, for open and for closed circuit.
Portable Storage Cells.
Rheostats.
Electric Motor, ⅛ H. P.
Bunsen Burners.
Blast Lamp.
Foot Blower.
Drawing Instruments.
Projection Lantern.

Supplies

Wire; brass, iron, steel, copper, of various sizes.
Insulated wire; heavy, for connections; bell wire; cotton or silk covered magnet wire of various sizes.

Rubber Tubing.
Glass Tubing, various sizes.
Asbestos Board and Wire Gauze.
Corks, Ordinary and Rubber.
Cork Borer.
Pinch Cocks.
Filter Paper.
Absorbent Cotton.
Glass Beakers, a variety of sizes and shapes.
Crystallizing Dishes.
Evaporating Dishes, Porcelain.
Flasks, Wash Bottles and Drying Tubes.
Watch Glasses.
Graduates.
Bottles, Reagent and Common Stock.
Vaseline.
Watch Oil.
Machine Oil.
Sealing Wax.
Soft wax.
Shellac, flakes and solution.
Stop-cock Grease.
Emery, various grades.
Powdered Pumice.
Rouge.
Resin.
Paraffin.
Canada Balsam.
Mercury.
Acids, C. P., Sulphuric, Hydrochloric and Nitric.
Alcohol, Ethyl.
Ether.
Carbon Disulphide.
Glycerine.
Ammonia.
Potassium Hydroxide.
Sodium Chloride (common salt).
Borax.
Copper Sulphate.
Calcium Chloride.

Tools

Bench Vise.
Hammers, Ordinary and Heavy and Light Machine Hammers.
Rawhide Mallet.
Drill Press and Drills.
Screw Drivers.
Files.
Hack Saw.
Pliers, Square, Round Nose and Wire Cutters, Tweezers.
Taps and Dies.
Metal Shears.
Wrenches.
Oil Stone.
Soldering Outfit.
Wood Working Tools—saws, planes, chisels, augers and bit brace, etc.
Stock of Machine and Wood Screws, Nails, Brads, Rivets, etc.
Sand and Emery Paper.

Measurements

Metric Models, Charts, etc.
Meter Scales of wood and metal.
Vernier Model, Vernier and Micrometer Calipers.
Micrometer Microscope.
Spherometer.
Level.
Demonstration Balance with weights.
Clock with arrangement for giving time signals.
Stop Watch.

Properties of Matter

Adhesion Disk.
Cohesion Plates.
Prince Rupert Drops.
Capillary Tubes and Support.
Osmose Apparatus.
Inertia Apparatus.
Elasticity of Flexure Apparatus.
Breaking Strength of Wire Apparatus.

Mechanics of Solids

Collision Balls.
Composition of Forces.
Models of Simple Machines, Block and Tackle, Differential Pulley, Wall Crane, Inclined Plane.
Center of Gravity Apparatus
Rotator, Whirling Table.
Centrifugal Hoop.
Gyroscope.
Spring Balances.
Jolly Balance.

Mechanics of Fluids

Equilibrium Tubes.
Hall's Pressure Gauge.
Bottle Imp and Jar.
Hydraulic Press.
Boyle's Law Tube.
Siphon.
Archimedes Principle Apparatus.
Lift Pump.
Force Pump.
Demonstration Hydrometer.
Hydrometer for heavy liquids.
Hydrometer Jar, 12x2½.
Barometer Tube, Cup and Pipette.

Pneumatics

Oil-sealed Air Pump.
Pressure Tubing.
Vacuum Gauge.
Bell in Vacuo.
Bursting Cubes.
Freezing Apparatus.
Bell Glass, 1 gallon.
Hand and Bladder Glass.
Sheet Rubber.
Mercury Shower.
Magdeburg Hemispheres.
Bacchus Illustration.
Water Hammer.
Guinea and Feather Tube.

Heat

Copper Boiler.
Air Thermometer.
Thermometers.
Heat Conduction Apparatus.
Ball and Ring.
Compound Bar.
Palm Glass.
Linear Expansion Apparatus.
Calorimeter.
Tyndall's Specific Heat Apparatus.
Fire Syringe.
Convection Apparatus.
Radiometer.
Sectional Model of Steam Engine.

Sound and Wave Motion

Savart's Wheel.
Siren Disk.
Tuning Fork.
Tuning Fork on Resonant case.
Helmholtz Resonators.
Sonometer.
Violoncello Bow.
Organ Pipes.
Chladni Plates and Clamp.
Oscillograph.
Kundt's Tube.
Crova's Disk.
Spiral of Brass Wire.

Magnetism

Lodestone.
Bar Magnet, 6 inch.
Horseshoe Magnet, 6 inch.
Iron Turnings.
Electro Magnet.
Magnetic Needle.
Compass, 40 mm.

Electricity

Friction Rod, wax.
Friction Rod, vulcanite.
Catskin.
Pith Balls, 1 dozen.
Pith Images, pair.
Electrical Pendulum.
Electroscope.
Toepler-Holtz Electric Machine with attachment and shocking handles.
Brass Chains with hook and snap.
Leyden Jar, quart.
Discharger.
Hollow Globe.
Proof Plane.
Geissler Tubes.
X-Ray Tube and Fluorescent Screen.
Induction Coil.
Electric Motor, Demonstration Model.
Decomposition of Water Apparatus.
Galvanometers with reading telescopes.
Contact Keys.
Wheatstone Bridges, slide wire and box form.
Resistance Boxes.
Ammeters and Voltmeters, various ranges for direct and alternating current.
Normal Cell.
Condenser.
Telephone and Telegraph Apparatus.

Light

Newton's Disk.
Concave and Convex Mirrors.
Multiple Image Apparatus.
Incidence and Reflection Apparatus.
Sextant.
Equilateral Prism.
Demonstration Lenses of various types and focal lengths.
Optical Bench with lens sup ports, slit, biprism, screen, eye piece, etc.
Iceland Spar.
Newton's Rings.
Nicol Prisms.
Replica Grating.
Spectrometer.
Microscope.

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	Sanitary and Applied Chemistry.
Baskerville	General Inorganic Chemistry.
Baskerville and Curtis	Laboratory Manual.
Baskerville and Curtman	Qualitative Analysis.
Benson	Industrial Chemistry.
Bigelow	Physical Chemistry.
Blake	General Chemistry.
Blanchard	Synthetic Inorganic Chemistry.
Blount	Practical Electro-Chemistry.
Blucher	Modern Industrial Chemistry.
Bottger	Qualitative Analysis (Trans. by Smeaton).
Bradbury	Elementary Chemistry.
Browning	Introduction to the Rarer Elements.
Brownlee and others	Laboratory Manual.
	Principles of Chemistry.
	Chicago High School Manual of Chemistry.
Clark and Dennis	Elementary Chemistry.
	Laboratory Manual.
Classen	Electrochemical Analysis.
Cohn	Tests and Reagents.
	Indicators and Test Papers.
Cumming and Kay	Qualitative Chemical Analysis.
Dennis	Gas Analysis.
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Duncan	The New Knowledge.
Erdman-Dunlap	Introduction to Chemical Preparations.
Fraps	Principles of Dyeing.
Freer	Elements of Chemistry.
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Garvin	Qualitative Analysis.
Gattermann	Practical Methods of Organic Chemistry (Trans. by Shober).
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Gooch and Walker	Outlines of Inorganic Chemistry.
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Hilly	Laboratory Manual of Chemistry.

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Rogers	Manual of Industrial Chemistry.
Rolfe	The Polariscope in the Chemical Laboratory.
Roscoe	Lessons in Elementary Chemistry.
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PROBLEMS

THE METHOD OF SOLVING CHEMICAL PROBLEMS

(From Talbot's Quantitative Analysis, by permission.)

Detailed solutions of a few typical problems are given below. The student should study these carefully, and assure himself that they are fully understood.

1. A "chemical factor" expresses the ratio between a specific quantity of a chemical compound and the *equivalent* quantity of some other body. For example, if it is wished to determine the weight of sulphur which corresponds to a specific weight of barium sulphate, the latter is multiplied by the factor, or ratio, represented by the fraction $\frac{S}{BaSO_4}$, or $\frac{32.07}{233.50} = 0.1373$. It may also be expressed by the proportion $\overset{233.5}{BaSO_4} : \overset{32.07}{S} = \text{wt. } BaSO_4 : x$, from which it is plain that $x = \frac{32.07}{233.50} \cdot \text{wt. } BaSO_4$.

Again, if the weight of FeO in Fe_2O_3 is desired, the factor becomes $\frac{2\,FeO}{Fe_2O_3} = \frac{144.04}{160.04} = 0.9000$. Similarly, the factor for the conversion of KCl to K_2O is $\frac{K_2O}{2\,KCl} = \frac{94.22}{149.12} = 0.6320$. The logarithmic equivalents of these values are called log factors.

In the calculation of these factors, the atomic or molecular relations of the two substances must be kept clearly in mind; thus, it is plainly *incorrect* to express the ratio of ferrous to ferric oxide by the fraction $\frac{FeO}{Fe_2O_3,}$ since each molecule of the higher oxide must correspond to two molecules of the lower. Carelessness in this respect is one of the most frequent sources of error.

2. To calculate the volume of a reagent required for a specific operation, it is necessary to know the exact reaction which is to be brought about, and, as with the calculation of factors, to keep in mind the molecular relations between the reagent and the substance reacted upon. For example, to estimate the weight of barium chloride necessary to precipitate the sulphur from 0.1 gram of pure pyrite (FeS_2), the proportion should stand $\overset{488.70}{2BaCl_2.\,2\,H_2O} : \overset{120.16}{FeS_2} = x : 0.1$, where x represents the weight of the chloride

*Talbot's "Quantitative Analysis."

required. Each of the two atoms of sulphur will form a molecule of sulphuric acid upon oxidation, which, in turn, will require a molecule of the barium chloride for precipitation. To determine the quantity of the barium chloride required, it is necessary to include in its molecular weight the water of crystallization, since this is inseparable from the chloride when it is weighed. This applies equally to other similar instances.

If the strength of an acid is expressed in percentage by weight, due regard must be paid to its specific gravity. For example, hydrochloric acid (sp. gr. 1.12) contains 23.8 per cent HCl by weight; *i.e.*, 0.2666 gram.

3. No rules for universal application to "indirect gravimetric analyses" can be laid down. A single example will be explained.

Given a mixture of KCl + NaCl weighing 0.15 gram, which contains 53 per cent chlorine, to calculate the weight of KCl and NaCl in the mixture.

The weight of chlorine in the mixture is (0.15×0.53) or 0.0795 gram. Assuming that this chlorine was all in combination with potassium, the corresponding weight of KCl would be 0.1672 gram (Cl : KCl = 0.0795 : 0.1672). This is an excess of 0.0172 gram over the actual weight of the mixture, and it is plain that this difference is occasioned by the replacement of certain of the molecules of potassium chloride, weighing 74.56 units, by molecules of sodium chloride weighing 58.50 units. To express this, let it be supposed that the mixture is made up of n molecules KCl and n' molecules NaCl; then it may be said that $n\,\overset{74.56}{\mathrm{KCl}} + n'\,\overset{58.50}{\mathrm{NaCl}} = 0.15$ gram, and $n\,\overset{74.56}{\mathrm{KCl}} + n'\,\overset{74.56}{\mathrm{KCl}} = 0.1672$ gram, then by subtracting the first equation from the second it is shown that $n'\,(\overset{74.56}{\mathrm{KCl}} - \overset{58.50}{\mathrm{NaCl}}) = 0.0172$ gram. That is, the difference in weight is equal to n' times the difference in the molecular weights of the two chlorides. The actual weight of NaCl present (x) is equal to $58.50n'$, or, since $n' = \dfrac{0.0172}{74.56 - 58.50}$, $x = 58.50\left(\dfrac{0.0172}{74.56 - 58.50}\right)$. This may be expressed in the form $(74.56 - 58.50) : 58.50 = 0.0172 : x$, from which $x = 0.0626$. The weight of NaCl subtracted from that of the mixture gives the weight of KCl.

The weights of the chlorides may also be calculated algebraically by solving the equations $x + y = 0.15$ and $\dfrac{35.45}{74.56}x + \dfrac{35.45}{58.50}y = 0.0795$, where x is the weight of KCl and y is the weight of NaCl in the mixture.

4. It is sometimes desirable to weigh out such a quantity of substance for analysis, that the number of cubic centimeters of standard solution entering into the reaction shall represent directly the percentage of the desired constituent. This may be readily done, by considering the relation of the solution to a normal solution and the atomic or molecular weight of the desired component. For example, suppose it is desired to calculate such a weight for K_2CO_3 in pearl ash, when a half-normal acid solution

is used. Since half-normal acid and alkali solutions are equivalent, and since by definition the half-normal K_2CO_3 solution contains 34.55 grams per liter, each cubic centimeter of the acid solution must be equivalent to 0.03455 gram K_2CO_3. Hence, 100 cc. would neutralize 3.455 grams pure K_2CO_3 and this becomes the desired weight of the pearl ash. Similarly the required weight of limonite where the iron (Fe) is to be determined by means of a deci-normal $K_2Cr_2O_7$ solution is 0.5602 gram.

5. One of the most frequently recurring cases in volumetric analysis is that in which it is wished to express the value of a specific solution in terms of some substance other than that against which it has been standardized as for instance, the value of a permanganate solution which has been standardized against oxalic acid, in terms of iron. Although such problems apparently vary widely, there are common principles which can be applied to them all. These are stated below, and the student should assure himself that they are fully understood.

Suppose, for example, it is desired to find the iron value (Fe) of a permanganate solution, of which 1 cc. is equivalent to 0.006302 gram $C_2H_2O_4 . 2H_2O$.

From a comparison of the reactions it is seen that 10 molecules of ferrous sulphate and 5 molecules of oxalic acid each react with the same amount (2 molecules) of the permanganate. These two quantities being, then, equivalent to the same third quantity, must be equivalent to each other; in other words, 10 molecules of ferrous sulphate and 5 molecules of oxalic acid have the same reducing power. But, as stated above, the value is desired in terms of metallic iron (Fe), not $FeSO_4$, but as it is plain that $10FeSO_4$ are equivalent to 10Fe, it is proper to make the proportion

$$\overset{560.2}{10\,\mathrm{Fe}} : \overset{630.25}{5C_2H_2O_4 . 2\,H_2O} = x : 0.006302$$

in which $x = 0.005602$ gram. Here, again, as in example 2, it is necessary to include the water of crystallization in the molecular weight of the oxalic acid, as it is weighed with it.

The same conclusion is arrived at, if we consider the relation of the solution to the normal. As given, it is deci-normal and must, therefore, be equivalent to a deci-normal solution of iron. From the equations cited, it is seen that $10FeSO_4$, unite with 5O, therefore each molecule is equivalent to 1 hydrogen atom in reducing power. The normal solution must, then, contain 1 gram-molecule of ferrous sulphate, or 56.02 grams Fe, and each cubic centimeter of the deci-normal solution would contain 0.005602 gram, the value obtained above.

Again, suppose the value of the same permanganate solution were desired in terms of molybdenum (Mo), the reactions with permanganate being

$$5Mo_{12}O_{19} + 17Mn_2O_7 = 60MoO_3 + 34MnO, \text{ and}$$
$$5C_2H_2O_4 . 2H_2O + Mn_2O_7 = 2MnO + 10CO_2 + 15H_2O.$$
$$(Mn_2O_7 \text{ is the anhydride of } HMnO_4.)$$

It is plain that in these equations as they stand, the molecular quantities of oxidizing agent are not equal. They can be made so by simply multiplying the second equation by 17, and they then become,

$$5Mo_{12}O_{19} + 17Mn_2O_7 = 34MnO + 60MoO_3, \text{ and}$$
$$85C_2H_2O_4 \,.\, 2H_2O + 17Mn_2O_7 = 34MnO + 170\ CO_2 + 255\ H_2O.$$

It is now possible to reason in the same way as before, and to conclude that 85 molecules of the oxalic acid have the same reducing power as 5 molecules of the oxide $Mo_{12}O_{19}$, or 60 atoms of molybdenum. Accordingly,

$$\overset{5758.8}{60Mo} : \overset{10714.25}{85C_2H_2O_4.2H_2O} : : x : 0.006302$$

in which x 0.003387 gram.

Since $5Mo_{12}O_{19}$ unite with 85O, a normal solution of the former as a reducing agent, would contain 1/170 of the 5 gram-molecules or 33.87 grams Mo, and the deci-normal solution 3.387 grams per liter. This agrees with the values already obtained.

6. It is sometimes necessary to calculate the value of solutions according to the principles just explained, when several successive reactions are involved. Such problems may be solved by a series of proportions, but it is usually possible, after stating these to eliminate the common factors and solve but a single one.

For example, suppose it is desired to express the value of a permanganate solution, of which 1 cc. = 0.008 gram iron (Fe), in terms of calcium oxide (CaO). The reactions involved in the volumetric determination of calcium are the following; $CaCl_2 + (NH_4)_2C_2O_4 = CaC_2O_4 + 2NH_4Cl$; $CaC_2O_4 + H_2SO_4 + 2H_2O = CaSO_4 + C_2H_2O_4 \,.\, 2H_2O$; $5C_2H_2O_4 \,.\, 2H_2O + 2KMnO_4 + 3H_2SO_4 = K_2SO_4 + MnSO_4 + 10CO_2 + 18H_2O$.

From the considerations stated under 5, the following proportions may be made.

$$10Fe : 5C_2H_2O_4 \,.\, 2H_2O = 0.008 : x$$
$$5C_2H_2O_4 \,.\, 2H_2O : 5CaC_2O_4 = x : y$$
$$5CaC_2O_4 : 5CaO = y : x$$

Canceling the common factors, there remains simply

$$\overset{560.2}{10Fe} : \overset{280.4}{5\ CaO} = 0.008 : z$$

Similarly, from the reactions, the equivalent of the iodine liberated may be calculated in terms of MnO_2 as follows: Supposing the weight of iodine to be 0.5 gram then

$$2I : 2KI = 0.5 : x$$
$$2KI : 2Cl = x : y$$
$$2Cl : 2HCl = y : z$$
$$2HCl : MnO_2 = z : w$$

Canceling the common factors, there remains

$$2I : MnO_2 = 0.5 : w$$

To solve such problems as 5 and 6, it is necessary to know the reactions involved, and the way in which the various components break up; then to compare the reactions and to search for those molecular quantities of the compounds in question, which are *equivalent* in their action upon a common agent. Having found these, as shown above, express the molecular ratio between them in the form of a proportion; as, for example, $\overset{253.7}{2\ \mathrm{I}} : \overset{86.99}{\mathrm{MnO_2}} = 0.5 : w$. Expressed in the form $w = \frac{86.99}{253.7} 0.5$, it is plain that this ratio is in no way different in principle from the chemical factor mentioned in paragraph 1; indeed, it is the factor for the conversion of iodine to manganese dioxide.

PROBLEMS IN ELEMENTARY PHYSICS

1. A map is drawn to the scale 1 mile to the inch. What area on the map in square centimeters represents 10 square miles? Ans. 64.5 sq.cm.

2. Express a velocity of 2500 cm. per second in feet per minute. Ans. 4921.2 feet per minute.

3. A rectangular tank 15 cm.×163 mm.×6 meters, inside measurements, is filled with water. Express the mass of the water in kilograms. One c.cm. of water weighs 1 gram (approximately). Ans. 14.67 kg.

4. The radius of a circle is 12 cm., what is the angle in degrees subtended by an arc of 16 cm.? Ans. 76.39°.

5. The pitch of the screw in a micrometer caliper is 0.5 mm.; the rotating head of the instrument carries 50 divisions; the vernier of the shank over which the head turns has 10 divisions which occupy the space of 9 smallest divisions on the head. What is the smallest distance which can be measured without estimation? Ans. 0.001 mm.

6. How far from the point of observation must a scale be placed in order that 1 cm. on the scale will subtend an angle of 1 minute? Ans. 3438 cm.

7. A river is 1 kilometer in width, and the current has a velocity of 4 km. per hour. What direction must be taken by a launch moving at 8 km. per hour in order to land directly opposite the starting point? What will be the total time for the trip? Ans. The launch must steer 30° upstream; 8.7 minutes.

8. A pendulum having a period of 1 second and a pendulum of nearly the same period are arranged so that it is possible to observe when the two reach the mid point of their respective oscillations at the same instant going in the same direction. The time elapsing between coincidences is 106 seconds. If the unknown is shorter than the known pendulum, what is its period? Ans. 0.9906 sec.

9. A body starts from rest and moves for 10 seconds with a uniform acceleration of 5 cm./sec.^{2}, for the next 20 seconds it moves uniformly at the velocity acquired and is finally brought to rest with a uniform acceleration of -5. cm./sec.^{2}, what is

the total space covered and the time occupied? Ans. 1500 cm., 40 sec.

10. Find the value of a constant force which, acting on a mass of 500 grams for 2 seconds, produces an increase in velocity of 10 cm./sec. Ans. 2500 dynes.

11. What is the weight in dynes of a sphere whose mass is 100 grams? If a spherical mass of 1000 kg. is placed vertically beneath the body so that their centers are separated by a distance of 50 cm., what is the apparent increase in weight? (g. = 980. cm./sec.^{2}, the gravitational constant $= 6.66 \times 10^{-8}$, C. G. S.) Ans. 98,000 dynes; .0026 dyne.

12. A uniform bar, 100 cm. long, is supported on a knife edge 30 cm. from one end. A mass of 500 g. is suspended at a distance of 5 cm. and a mass of 200 g. at a distance of 60 cm from the same end. If the system is in equilibrium, what is the mass of the bar? Ans. 325 g.

13. The beam of a balance is 25 cm. long and weighs 50 g. If the center of gravity is 0.05 cm. below the central knife edge through what angle will the beam be deflected by the addition of 0.001 gram to one of the pans? Ans. 0° 17.2′.

14. The mean radius of the earth is about 6,370,000 meters. What is the acceleration toward the center of a point on the equator due to the rotation of the earth? Ans. 2910.3 meters per sec. per sec.

15. If the period of simple harmonic motion is 10 seconds and the amplitude 20 cm., what is the displacement, velocity and acceleration 2 seconds after the particle has passed its mid point in a positive direction? Ans. Displacement 19.02 cm., velocity 3.88 cm./sec., acceleration -7.51 cm./sec.^{2}.

16. A body of 60 g. mass falls freely from rest for 6 seconds, what is its momentum and kinetic energy at the end of the period? (g. = 980 cm./sec.^{2}.) How far does the body fall? How much work would be done in raising it to its original position? Ans. Momentum, 352,800 g. cm./sec.; kinetic energy, 1.037×10^9 ergs; space passed over 17,640 cm.; potential energy (mgh) 1.037×10^9 ergs.

17. What power is delivered by a hoisting engine in pulling a mass of 200 kg., (1) Upward against gravity, 5 meters per second; (2) along a horizontal plane whose coefficient of friction with the block is 0.20 at the rate of 2 meters per second; (3) along a perfectly smooth (frictionless) horizontal plane at any velocity; (4) up an incline of 45° with the horizontal with a coefficient of friction of 0.1 at the rate of 1 meter (measured along the incline) per second? (The hoisting apparatus is to be considered frictionless.) Ans. (1) 980 watts. (2) 784 watts. (3) No work is done. (4) 15,240 watts.

18. A bullet fired from a gun 1 cm. in internal diameter and 75 cm. long has a muzzle velocity of 500 meters per second. What uniform pressure in the barrel would cause this velocity if the bullet weighs 25 g.? Ans. 1.061×10^9 dynes per sq. cm.

19. The pitch of a jack screw is 1 cm; the power is applied at the end of a lever 24 cm. long. When force of 30,000 dynes is applied at the lever the lifting force is 1,200,000 dynes, what

portion of the force applied is used to overcome friction? What is the efficiency? Ans. 22,040 dynes; 34.1%.

20. It is required to find the density of a cylinder of alloy. A ballast load is placed on one pan of the balance, which requires 292.560 g. to counterbalance. The sample is added to the pan containing the weights and the amount to effect equilibrium is reduced to 88.480 g. When the sample is suspended below the pan in water (density 0.9977) the mass necessary in the pan is 148.627 g. The density of the brass weights was 8.45, the density of air at the temperature and pressure of the experiment 0.00115. Find the true density, making correction for buoyancy of the air. Ans. 3.383.

21. The cross-section of the stem of an hydrometer has an area of 0.2 sq.cm. The total volume immersed when the instrument floats in water at 4° C. is 6. cu.cm. If in another liquid the hydrometer sinks until 8 cm. additional length of stem is immersed, what is the specific gravity the liquid? Ans. 0.7894.

22. The volume of the cylinder of an air pump cleared at each stroke of the piston is 2000 cc. If the volume of the vessel to be exhausted with connecting tubes is 4000 cc., what pressure should be obtained by 10 strokes? Ans. 0.0173 the original pressure.

23. Water at a temperature of 20.3° C. rises to a height of 6.128 cm. in a tube whose radius is 0.0247. Compute the surface tension, taking g. = 980. Ans. 74.15 dynes/cm.

24. A glass tube closed at one end is 100 cm. long. A column of mercury 91 cm. long is poured into the tube and it is then inverted with the lower (open) end in a dish of mercury. The air now fills 40 cm. at the top of the tube and a column of mercury 58 cm. long is supported below. What is the barometric pressure? Ans. 74.84 cm.

25. A wire 100 cm. long and 0.3 mm. in radius is stretched 2 mm. by the addition of a weight of 10 kilos. Compute the value of Young's Modulus. Ans. 17.3×10^{11} dynes/sq.cm.

26. The thermal coefficient of linear expansion of brass is 0.000018. A cylindrical bar is 100 cm. long at 20° C. and has a density of 8.450, what is the length and density at 0° C? Ans. Length 99.964 cm., density 8.451 g./cm.^{3}.

27. A steel rod is measured with a brass scale at 15° C. The rod appears to be 200 cm. long. The scale is correct at 0° C. What is the true length of the rod at 0°? The coefficient of expansion for steel is .000011. Ans. 200.021 cm.

28. If the volume of a portion of gas is 1000 ccm. under a pressure of 30.5 cm. of mercury and at a temperature 0° C., what will be the volume under a pressure of 29.5 cm. and a temperature of 20° C.? Ans. 1109 c. cm.

29. The mass of a copper calorimeter is 110 grams. It contains 400 grams of water at a temperature of 16° C. A solid mass of 60 grams at a temperature of 98° C. is placed in the water. The temperature reaches equilibrium at 21° C. Neglecting radiation, find the specific heat of the solid. Ans. 0.443 cal./g.

30. Two hollow brass cones fit together and are arranged so that the outer cone can be rotated while the inner cone may be held stationary by the application of a force sufficient to overcome the friction between the cones. A horizontal pulley 30 cm. in diameter is attached to the inner cone and a cord wrapped around this pulley and passing over another pulley at the side supports a weight of 100 grams. The mass of the two cones is 400 g., and 25 cc. of water is placed in the inner cone. The outer cone is rotated rapidly enough to keep the weight suspended and makes 1500 revolutions. What temperature change will occur in the cones, neglecting radiation? (The mechanical equivalent of heat is 4.18×10^7 ergs.) Ans. 5.33° C.

31. A source of sound whose frequency is 2000 per sec. is moving toward the observer at the rate of 7200 kilometers per hour. The temperature of the air is 20° C. What is the apparent pitch? Ans. 2116.4 per sec.

32. What are the relative potentials of two insulated conducting spheres charged with equal quantities of electricity if their radii are 5 and 10 cm. respectively? Ans. 2 to 1.

33. What is the force acting between two concentrated positive charges of 6 and 8 units, separated by a distance of 4 cm. in air? Ans. 3 dynes.

34. What is the resistance of 48,500 cm. of copper wire 1 millimeter in diameter at 0° C.? The specific resistance of copper is .0000017. Ans. 0.26 ohm.

35. A circuit is composed of 8 cells in two groups. The two groups are in parallel and each consists of 4 cells in series. The electromotive force of each cell is 1.4 volts and the internal resistance 0.1 ohm. The external circuit consists of a series of 5 coils, each having a resistance of 200 ohms. If a galvanometer whose resistance is 1000 ohms is placed in parallel with one of the coils, what current will flow through the galvanometer? Ans. 0.0011 amp.

36. A cell whose electromotive force is 1 volt and internal resistance 5 ohms is connected in series with a resistance of 2000 ohms and a galvanometer whose resistance is 98 ohms. The galvanometer terminals are connected by a shunt having a resistance of 1 ohm and the scale is 25 cm. from the mirror. The deflection, observed by a telescope, is 0.55 cm. What is the figure of merit—that is, the current which would cause a scale deflection of 1 mm. if the scale were 1 meter from the mirror? Ans. 0.000000229 amp.

37. The horizontal intensity of the earth's magnetism at a certain locality is 0.20 gauss and the dip is 70°; what is the value of the total intensity? Ans. 0.585 gauss.

38. A standard candle and an electric incandescent of unknown intensity are 500 cm. apart. A photometer screen shows even illumination when placed 100 cm. from the candle. The standard candle is found to have consumed spermaceti at the rate of 124 grains per hour during the test. If the intensity of the candle is 1 international candle when burning 120 grains per hour, what is the horizontal candle power of the unknown? Ans. 15.47 international candles.

39. An object 43.6 cm. from a concave spherical mirror gives a sharp image 66.5 cm. from the mirror; find the principal focus and radius of curvature of the mirror. Ans. Focus 26.33 cm., radius of curvature, 52.6 cm.

40. Light divergent from a point source 20.5 cm. from a double concave lens has its divergence increased by the lens so that it appears to come from a point 113.9 cm. from the lens (on the same side as the source). The radius of curvature of both faces is 25.1 cm., what is the principal focus and index of refraction of the lens? Ans. Principal focus −25.0 cm.; index of refraction 1.50.

41. The angle of minimum deviation of a prism is observed and found to be 60° 2.5′. If the angle of the prism is 59° 54′, what is the index of refraction of the material of the prism? Ans. 1.734.

INDEX

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RUBBER TUBING

Rubber tubing suitable for chemical laboratory work must be of special composition to withstand the hard usage and particular requirements.

Serious difficulty and embarrassment will result should it give out unexpectedly in the midst of an important experiment.

The various grades of tubing herein listed are especially compounded to meet the demands of the Chemical Laboratory — a selection based upon the recommendation of Professors in charge of some of the largest high schools and colleges throughout the United States.

Several years of successful use of these tubings in the largest and most important laboratories of the country has convinced us of their superiority for the work.

The same high standard of quality will be maintained, as we realize the importance of supplying the trade with such goods as will prove satisfactory and add to our long list of patrons.

The compounds of our various tubings are carefully made and contain no foreign substance which might cause rubber to deteriorate.

The various materials are chosen with the object of supplying a product of low specific gravity. The compound is not adulterated in order to accomplish this, therefore we are able to give an unusual number of feet of tubing per pound. All grades of tubing are of the lowest specific gravity consistent with good quality of stock.

Rubber tubing may be had in five different grades which are especially adapted to the various laboratory work. We also give a list showing the approximate number of feet per pound of tubing from which the cost per foot can be quickly computed for the various sizes and grades.

No. 423 White Wrapped Tubing
No. 435 White Wrapped Pressure Tubing
No. 462 Antimony Tubing
No. 508 Antimony Tubing, hand made
No. 572 Pure Gum Tubing, hand made

Inside Measurements.	Approximate Number of Feet per Pound Tubing.				
	No. 572.	No. 508.	No. 462.	No. 435.	No. 423.
$\frac{1}{8}$ inch.......	150	110	77	20	64
$\frac{3}{16}$ "	65	53	39	13	33
$\frac{1}{4}$ "	48	36	25	10	22
$\frac{5}{16}$ "	32	25	19	8	17
$\frac{3}{8}$ "	22	16	14	6	13
$\frac{1}{2}$ "	17	13	9	5	8

Pure Gum Tubing carried in stock in $\frac{5}{8}$ and $\frac{3}{4}$ in. All other sizes not listed, made to order.

RUBBER STOPPERS

The compound used in our rubber Stoppers has received the same consideration and careful selection as our Rubber Tubing. The points considered were to obtain a compound of exceptional wearing quality, at the same time have a maximum flexibility which would be retained as long as the life of the stopper, the lasting qualities of the stock being of most importance.

These stoppers are made in the sizes termed "The New Chemists' Style." The taper is such as will make a most suitable and tight joint. Three styles of stoppers are carried in stock in all sizes mentioned with one-hole, two-hole and without holes. In addition three-hole stopper can be furnished when ordered in quantities which permit of special manufacture and can be had in two weeks from date of order.

The holes are of different size, depending upon size of stopper, graduated from $\frac{3}{32}''$ in the No. 00 to a $\frac{5}{16}''$ hole in the No. 13 stopper. This is essential on account of the larger tubing required where large stoppers are used, also on account of impracticability of a large hole in small stopper.

The approximate number of stoppers per pound is shown on the list, from which the cost per dozen can be readily computed. You will note that all prices on rubber material are per pound. This we find most satisfactory, as it does not burden certain sizes with additional charge to overcome a lower quotation on other sizes. You can readily realize the impossibility of figuring the prices accurately and giving a just price on all the various sizes due to slight fluctuations in weight.

No. 483 Chemists' Stoppers

Carried in stock in sizes Nos. 00 to 13. Solid, One Hole or Two Holes.

Order by No.	Approximate No. of Stoppers per Pound.	Diameter at Top.	Diameter at Bottom.	Length.
00	150 per lb.	$\frac{17}{32}$ in.	$\frac{11}{32}$ in.	$\frac{7}{8}$ in.
0	80 "	$\frac{21}{32}$ "	$\frac{15}{32}$ "	1 "
1	65 "	$\frac{3}{4}$ "	$\frac{9}{16}$ "	1 "
2	50 "	$\frac{25}{32}$ "	$\frac{19}{32}$ "	1 "
3	40 "	$\frac{29}{32}$ "	$\frac{23}{32}$ "	1 "
4	33 "	1 "	$\frac{25}{32}$ "	1 "
5	26 "	$1\frac{1}{16}$ "	$\frac{29}{32}$ "	1 "
6	20 "	$1\frac{1}{4}$ "	1 "	1 "
7	15 "	$1\frac{1}{2}$ "	$1\frac{5}{32}$ "	1 "
8	12 "	$1\frac{5}{8}$ "	$1\frac{9}{32}$ "	1 "
9	10 "	$1\frac{23}{32}$ "	$1\frac{7}{16}$ "	1 "
10	7 "	$1\frac{15}{16}$ "	$1\frac{21}{32}$ "	$1\frac{1}{32}$ "
11	6 "	$2\frac{1}{4}$ "	$1\frac{29}{32}$ "	1 "
12	$5\frac{1}{2}$ "	$2\frac{1}{2}$ "	$2\frac{3}{32}$ "	$1\frac{7}{32}$ "
13	5 "	$2\frac{11}{16}$ "	$2\frac{1}{4}$ "	$1\frac{1}{8}$ "

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17
16
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9

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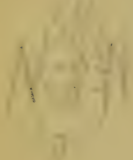
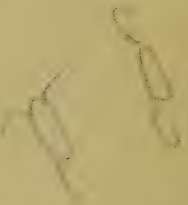
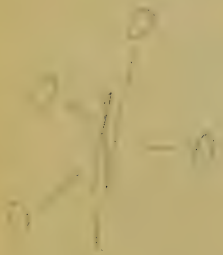
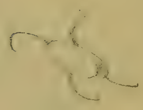
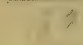
N_2O_5











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